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Inequality and Macroeconomic Dynamics: An Agent-Based Model

Supervisor

Prof. Andrea Roventini

Candidate

Elisa Palagi

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1 Introduction

This thesis presents an analysis with an agent-based model on the links between inequality and macroeconomic dynamics in an environment characterized by credit rationing. It investigates how different scenarios of inequality can impact on the evolution of aggregate income. On the policy side, this work tries to understand the possible role redistributive fiscal policies can have in the economy, and whether they can work as automatic stabilizers. The model presented by Napoletano, Roventini and Gaffard (2015) is expanded and adapted to this analysis.

In the last decades, most advanced countries have experienced a rising trend in inequality of both income and wealth. This process has culminated with the example of contemporary United States exhibiting an extremely concentrated distribution of income and wealth, with the top 10% earning 50% of total income and owning 70% of total wealth (Piketty, 2014). Only recently, a number of economists have rediscovered the importance of distributional issues for the understanding of macroeconomic dynamics. The public opinion has also started to be more aware of the issue of the top percentile earning and owning an increasing share of respectively income and wealth. The manifestation of this phenomenon has been the great success Piketty's "Capital in the Twenty First Century" received when published in 2014. However, a lot of work remains to do in understanding the links between inequality and macroeconomic dynamics.

Empirically, both wealth and income have followed a u-shaped evolution since 1900, both in Europe and US, starting with highly concentrated distributions at the beginning of last century. After the two World Wars inequality was at its lowest levels, until the 1970s, when it started rising again, reaching record high levels in 2010.

From a theoretical point of view, many schools of thought, as the Classical, Marxian, Keynesian and Post-Keynesian have been aware of the importance of distributional issues for the understanding of economic dynamics. Neoclassical economics, which identifies mainstream economics, has, however, for decades almost completely neglected this issue. Only recently, some neoclassical models have tried to take into account some form of heterogeneity, although mainly con-

sidering pre-determined categories of agents (Fagiolo and Roventini, 2016).

After the crisis, inequality has been central in most economic debates. Some economists as Stiglitz (2012) and Fitoussi (2013) claim that rising inequality in the last decades could be at the roots of the Great Recession. In line with Kaldor's theory, they find in the widespread increase of inequality the cause of a depressed aggregate demand. In fact, rising inequality transfers resources from households characterized by a high propensity to consume to households with a lower propensity to consume. On the aggregate, this results in lower consumption. This lack of demand was not visible prior to the crisis, because of an increase in households debt. In fact, monetary policy maintained low interest rates, which allowed private debt to increase beyond sustainable levels. It was only through borrowing that most households were able to satisfy their consumption needs. This, together with a continuous search for high-return investments by those at the top of the income distribution, caused the explosion of the bubble.

It is therefore crucial to understand distributional dynamics and the possible impacts they can have at aggregate level (Stiglitz, 2011).

In order to do so, households heterogeneity is a crucial aspect to take into account. Therefore, the representative agent assumption used in standard theories fails at explaining inequality and its impact on macroeconomic dynamics. For this reason, agent-based modeling is used in this analysis in order to take into account heterogeneity and interactions among agents with bounded rationality. Agent-based modeling can be used as a laboratory in order to analyze complex emergent properties of the system that stem from repeated microinteractions of simple entities (Kirman, 1998).

This agent-based model is characterized by multiple households which are heterogeneous in a number of characteristics such as income, wealth and access to credit. Starting from a quite egalitarian income distribution, the economy is hit after some periods by an inequality shock, which affects households income distribution, making it more skewed. In particular, three different types of inequality shocks are introduced, ranging from one characterized by low inequality in the income distribution to one generating a highly skewed distribution. The dynamics of the system are analyzed relatively to different degrees of government

intervention. Moreover, in addition to comparing different intensities of direct government consumption, this version of the model adds the possibility of introducing a subsidy targeted towards low-income households, as a response to the crisis.

Simulation results permit to analyze the response of the economy to the inequality shock, in terms of aggregate income, fraction of constrained borrowers and evolution of fiscal multipliers.

What emerges from this analysis is that, as the evolution of aggregate income is demand-driven, in a Keynesian vein, the inequality shock leads to a recession and to a stagnation of GDP, which stays at lower steady-state levels after the economy is hit. In fact, when a higher degree of inequality is introduced, many households do not have sufficient resources in order to satisfy their consumption plans and they have to ask for credit. Credit supply is allocated through a pecking order (Dosi et al. 2013, 2015) that depends on the ratio between a household's wealth and his credit demand. This leads to the emergence of credit rationing in the economy and, thus, to lower demand. On the other side, some few households find themselves with an extremely high income, but they consume only a small fraction of it, such that what emerges is that they have a lower effective marginal propensity to consume, as also confirmed by empirical evidence (Jappelli and Pistaferri, 2013; Krueger, Mitman and Perri, 2016). Government expenditure can dampen the fall in aggregate income, helping households in repairing their balance sheets and sustaining household consumption.

The fall in aggregate income resulting from the introduction of an inequality shock is higher, the higher is the degree of inequality introduced. In fact, in the high inequality scenario, for every type of public policy considered, the recession is more severe and output stays at lower steady state levels. In fact, higher inequality is associated with a higher fraction of credit constrained households in the economy.

The introduction of a subsidy targeted towards low-income households works as an automatic stabilizer in the economy, in line with McKay and Reis (2016), considerably dampening the recession for all inequality shock scenarios considered. This positive effect of the subsidy is strongly amplified when the resources

collected by the government and used for redistributive aims are higher. Moreover, fiscal multipliers associated with the subsidy are significantly higher than the corresponding ones in presence of direct government consumption. In other words, the subsidy is more effective in dampening the negative effects of the shock, with respect to direct government consumption. In fact, the subsidy allows poor households to repair their balance sheets and to increase consumption.

The thesis is organized in the following way. Section 2 presents a summary of the empirical evidence on the main variables of interest, as wealth, income, divided between capital and labor income, together with some considerations about some main findings about the correlation between inequality, redistribution, macroeconomic dynamics and growth. Section 3 presents some main theories in the history of economic thought that have dealt with distributional issues, some more recent neoclassical models and some new frontier theories presented in the last few years. In Section 4, agent-based modeling is presented as a tool to investigate the role of inequality and fiscal policy in explaining macroeconomic dynamics, together with a short survey of agent-based models dealing with such issues. Section 5 presents the model utilized in this analysis and shows the main simulation results. Finally, in Section 6, some main conclusions are drawn from the analysis.

2 Empirical evidence

In this section, some empirical evidence on the evolution of wealth and income inequalities will be presented. While the former is a stock corresponding to the total wealth owned at a given point in time, accumulated in previous years, the latter is a flow, corresponding to the quantity of goods produced and distributed in a given period. I will mainly focus the analysis on advanced countries in the twentieth century and in the beginning of the twenty-first century. Thereafter, I will introduce some empirical findings on the correlation between inequality, macroeconomic dynamics and growth, together with some studies on the links between redistributive policies and the long-run performance of the economy.

I will hereby report the main conclusions of this chapter. Most studies in the literature find that inequalities, both with respect to income and wealth, have been growing in the last decades. In general, a stylized fact that emerges from these studies is that the distribution of wealth tends to be more unequal than the distribution of income.

Starting with wealth, and taking capital/income ratios as a measure of the stock of wealth in an economy, what emerges is a clear u-shaped evolution over time in most advanced countries. In fact, the ratio from being extremely high at the beginning of the twentieth century, fell after the destructions of the two World Wars. Since the 1980s, wealth has increased faster than income in most advanced countries, and therefore the trend in the capital/income ratio has been upward. In particular, the largest fortunes grew much more rapidly than average wealth (Piketty, 2014).

The same pattern of evolution characterizes the concentration of wealth in the population. From being highly concentrated in the top at the beginning of the twentieth century, wealth became more evenly distributed after the two World Wars and the Great Depression. The concentration of wealth in the hands of few rich increased from the 1970s on. United States is an example of a highly unequal distribution of wealth. In fact, in 2010 the top 10% held 70% of total wealth.

Income, which can be divided between income from capital and income from labor, has also followed a similar evolution in the last century, however with big differences among advanced countries. From being highly concentrated at the

beginning of the twentieth century, it became more equally distributed after the two World Wars. Possible explanations of this trend are given by the big capital destructions during the wars which prevented many rentiers from receiving high incomes from their capital, and the introduction of public policies after the wars. The degree of concentration of income in the top decile increased significantly again starting from the end of the 1970s, and reached particularly high levels in the US, while it stayed lower in Scandinavian countries, for example. These significant differences across countries suggest that public policies and institutions matter for the evolution of inequalities.

In particular, for what concerns capital income, defined as rents, dividends, interests, royalties, profits, capital gains, etc., its share in total income decreased significantly in the period starting with the end of WWI until the 1970s (Bengtsson and Waldenström, 2015). Since 1975, capital shares in income have then increased in most advanced countries. The concentration of capital income as well was much lower after the two World Wars with respect to the beginning of the century. A possible explanation of this evolution is given by the destructions of huge quantities of capital during the wars that also implied lower incomes derived from capital. Furthermore, in the following period, capital income concentration stayed low for some decades. It then started to rise again starting from the 1980s.

A possible explanation of such a trend is that in the first decades after the wars public policies prevented the restoration of big fortunes. However, more liberal policies introduced starting from the 1980s, made capital more profitable and introduced increasing possibilities for speculative gains. The concentration of capital income has increased in the last decade also due to the presence of different returns on capital and some increasing returns for individuals owning big quantities of wealth.

Turning to labor income, what emerges is that labor shares has been falling in the last decades. Moreover, there has been a trend in labor income which is similar to the one for total income distribution. In fact, also for labor income, inequalities were high at the beginning of the twentieth century both in Europe and in the US, falling until the 1970s and rising again after that. What emerges

is that the wage gap has widened, particularly in Anglo-Saxon countries, and that the share of income going to the top decile has increased in the last decades, mainly due to the explosion of high-executives' remunerations. Differences across countries are remarkable, again suggesting an important role for institutions and politics in shaping these mechanisms.

In Section 2.1 I will introduce some methodological considerations about the measurement of income and wealth inequality. I will then procede with an analysis of the evolution of wealth in Section 2.2. Section 2.3 focuses on income inequality, both deriving from capital and labor.

Section 2.4 shows how inequality may affect macroeconomic stability. For instance, some studies find that some major crisis were preceded by a period of increasing inequality, and analyze this phenomenon. About the links between inequality and growth two main streams of literature are reported, the first identified by those who find that inequality positively affects growth, the second composed by studies that find the relationship to be negative.

In section 2.5 empirical evidence is again contrasting, with some studies finding a negative effect of redistributive policies on growth, and some other studies finding the correlation to be positive.

2.1 Methodology

In this section I will often refer to the work of Piketty (2014), Capital in the Twenty-First Century, in which distribution deciles and percentiles are used in order to get a rigorous analysis of the distributions. It is therefore the case to introduce a brief discussion on why this methodology can be useful.

In many official reports, the Gini coefficient is often used to describe the evolution of inequality in a given country. The Gini coefficient can give a large picture of the situation of a country, but it is a too synthetic index in order to grasp the multidimensionality of inequality and the mechanisms at work in detail. It includes inequalities with respect to labor income and with respect to capital, mixed. Furthermore, it could be misleading to compare Gini coefficients referring to different countries and times, as the underlying data could be not comparable. For example, income from capital could be included in some countries, but not

in others.

Another widespread measure of inequality is the $P90/P10$ index. This index (or similar), often used in reports by the OECD or statistical agencies, may be useful to get a broad picture of the distribution, but it totally ignores the top 10 percent of the distribution, which may provide interesting information about the degree of inequality in a country. For the top 10 percent the data are often imperfect, but Piketty suggests that these difficulties can be overcome utilizing historical data as those in the World Top Incomes Database (WTID). The shares, used by Piketty, among others, give a much more complete picture, which attempts to be more close to reality.

Indeed, the top of the distribution matters from a macroeconomic perspective since it owns a huge share of aggregate wealth and accounts for a large fraction of its growth. In fact, in most countries, the changes, and particularly the recent increases, have been concentrated at the very top (Atkinson et al., 2011). Almost half of the aggregate wealth accumulation in the period 1986-2012 in the US has been due to the top 0.1 % (Saez Zucman, 2014). Atkinson et al. (2011) show that the share going to the top 0.1 % has more than quadrupled from 2.6 % to 12.3 % over the period 1976-2007.

Data about the top 0.1 % are usually hard to achieve with surveys as extremely rich (and poor) people tend to be undersampled as they don't want to disclose information about their income. That's why in many studies tax data are used.

Piketty uses the World Top Incomes Database for his analysis of the evolution of income and wealth. This database has been the fruit of the contribution of over fifty researchers in the last fifteen years, and it is based on income tax data, before tax.

With these data, capital income is therefore underestimated partly due to the erosion of capital income from the progressive income tax base (Atkinson et al., 2011), as, over time, many sources of capital income, as for example interest income, have been either taxed separately or fully exempted, partly due to tax evasion, particularly for what concerns investment income. This kind of income can, in fact, be hidden in the so called "tax heavens", and it is easier to hide than income from wages.

The important implication of this is that top incomes are underestimated, as it is the upper decile that owns the greatest amount of capital income. Ideally, one should impute excluded capital income back to each income group, but this is often difficult to do because of lack of data. Piketty claims that, probably, the overall evolution of income inequality would not change much, as under-reporting of capital income was a widespread phenomenon also a century ago. Roine and Waldenström (2010), in the case of Sweden, also argue that there is no reason to believe that under-reporting has changed dramatically over time. They argue that, while the incentives to under-report have increased, as tax rates have gone up over time, administrative controls have also been improved. In the case of Italy, Alvaredo and Pisano (2010) conclude that, even if tax evasion is an important phenomenon in the country, it is unlikely that evasion from self-employment and small business income account for the gap in the top incomes between Italy and Anglo-Saxon countries. On the other hand, inequality measured by these before-tax income data could be reduced once taxes and transfers are paid and when we move from individual to household incomes.

Another issue is that, while rents, interest and dividends are treated in a similar way in different countries, capital gains are often treated differently. While in French data they are not reported, they are included in US tax data. This can change a bit the results as capital gains are highly concentrated in the very top of the distribution. Another limitation of tax data is that you cannot attribute a certain income from capital to inherited capital or to capital accumulated by an individual during his lifetime through labor income accumulation. However, it is reasonable to think that for very large fortunes, inheritance is likely to play a crucial role.

Finally, Atkinson et al. (2011) point out that also differences between units of analysis in different studies can make comparability difficult. Units of analysis may be individuals, tax units combining incomes of husbands and wives, and households. For example, the increasing labor force participation of females means that the joint distribution of incomes is now more relevant than before, and the ageing of the population implies that we can find more single elderly people in the distribution.

Keeping in mind these limitations, I will in the next sections present the results obtained in different studies, most of them based on before-tax income data, on the different dimensions of income distribution and inequality.

Moreover, an analysis of the evolution of wealth in the last century in the main rich countries is presented. The focus will be on recent works, mainly relying on data from national balance sheets. This is a relatively new method of studying wealth, since lack of data has been a major issue for research in this field. Only in 1993 the System of National Accounts, giving the international standards for national accounting, introduced guidelines for the measurement of wealth. One of the first comprehensive studies of the topic is the one by Piketty and Zucman (2014), who use these stock, which include all non-financial and financial assets and liabilities held by each sector of the economy (households, government, corporations), in order to measure the stocks of private and national wealth at current market value.

2.2 Wealth inequality

Wealth refers to the stock of net worth, defined as the sum of assets minus liabilities at a given point in time.

A useful measure of the stock of wealth present within a country is given by the capital-income ratios [1]. In analyzing his data, Piketty detects a clear pattern in advanced countries' capital-income ratios . Taking as an example France, national capital was about seven times national income from 1700 to 1910. The capital-income ratio then fell to less than 3 in the period going from 1910 to 1950, most probably because of the occurrence of two World Wars and the Great Depression. This ratio then rose up to almost 6 in 2010. An analogous pattern is found for Great Britain. United States' capital-income ratio was about 3 in the late 18th century and it then increased to 5 in 1910. It was falling a bit in 1920, but soon reached 5-5.5 in 1930. In 1950 it decreased to below 4, and was then as high as 4.5 in 2010. He also makes a prediction about further rising ratios in the future.

Piketty and Zucman (2014) claim that the U-shaped evolution of European

[1]The terms wealth and capital are used interchangeably in Piketty (2014).

wealth-income ratios can be explained by the change in relative asset prices, driven by changes in capital policies. After World War I, asset prices fell due to the introduction of some "anti-capital" policies, i. e. capital controls, such as transaction taxes, foreign exchange controls, which restricts the amount of foreign currency or local currency that can be traded, limits on the allowed volume for international trade of financial assets. From the 1980s these restrictions were removed, contributing to the rise of asset prices. Another explaining factor they point out is the slowdown of productivity and population growth.

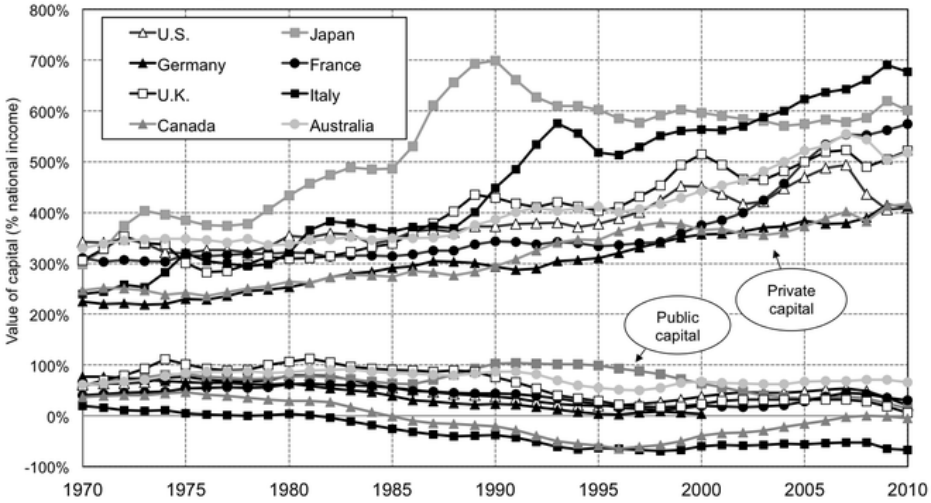

Figure 1: Private and public capital in rich countries, 1970-2010 (Piketty 2014, p. 184)

In Figure 1 it is clear how the evolution of wealth is following an upward trend since the 1970s in all major developed countries. Splitting up capital between private and public capital, it is interesting to see that this rise has affected only the former. For what concerns Italy, for example, private capital rose from 240 percent in 1970 to 680 percent in 2010, while public capital decreased from 20 to -70 percent of national income [2].

The rising quantity of private capital in the last decades, indicates an increasing importance of wealth with respect to labor income in the economy [3]. Since wealth is concentrated in the hands of few rich people, this suggests the presence of an increasing level of high inequality. Data from the European Central Bank (Franzini and Pianta, 2016) indeed show that, while the bottom 20 percent of

[2]For a deeper analysis on these issues see Piketty (2014), chapter 5.

[3]A discussion about differences between capital and wealth and issues in calculating it can be found in Stiglitz, J. (2015), The measurement of wealth: recessions,sustainability and inequality.

Europeans have a net wealth of basically 0, the richest 20 percent of Europeans own 68 percent of total wealth, of which the top 5 percent own 37.2 percent. Wealth inequality has worsened also in the Nordic countries, generally considered more egalitarian, but the strong presence of a welfare state makes it possible for households to avoid conditions of poverty in the majority of cases.

Wealth is highly concentrated in most advanced countries. Also for the case of the United States, a survey for the years 2010-2011 carried out by the Federal Reserve, estimates that the top 10 percent own 72 percent of the total wealth in the United States, whereas the bottom 50 percent own just 2 percent. Furthermore, it is important to recall that most self-reporting surveys underestimate the wealth of the richest wealth-owners.

Piketty (2014) shows that within the top 10 percent the composition of wealth varies significantly. Nearly everyone belonging to the group owns a real estate, but the weight it has on the total wealth decreases the further up in the distribution one gets. While for the lowest 9 percent of the group real estate accounts for half of the wealth, in the top 1 percent shares of stock or partnership account for almost the whole fortune. Financial and business assets is thus the primary source of wealth of the very rich. For the middle 40 percent, the one between the bottom 50 percent and the top 10 percent, wealth is mainly determined by the primary residence they own and some savings. The bottom 50 percent usually own close to nothing.

The evolution of the distribution of wealth in the last century started with societies in 1900-1910 in which the richest 10 percent owned 90 percent of the nation's wealth, for what concerns France, Britain, Sweden and all the countries Piketty has data for. More strikingly, the top 1 percent always owned more than 50 percent of the nation's wealth. The middle 40 percent owned between 5 and 10 percent of the total, depending on the country, while the bottom 50 percent owned less than 5 percent, as nowadays. There was no middle class, as the bottom 90 percent of the wealth distribution was more or less equally poor.

The emergence of a patrimonial middle class occurred later in the century, as today they own more than before, while for the bottom 50 percent nothing has really changed from 1900 to now. However, the middle 40 percent includes

four times as many people as the top 10 percent, and they own only one-half to one-third of their wealth. This suggests that even if some change has occurred for the middle class, inequality in the wealth distribution is still extreme.

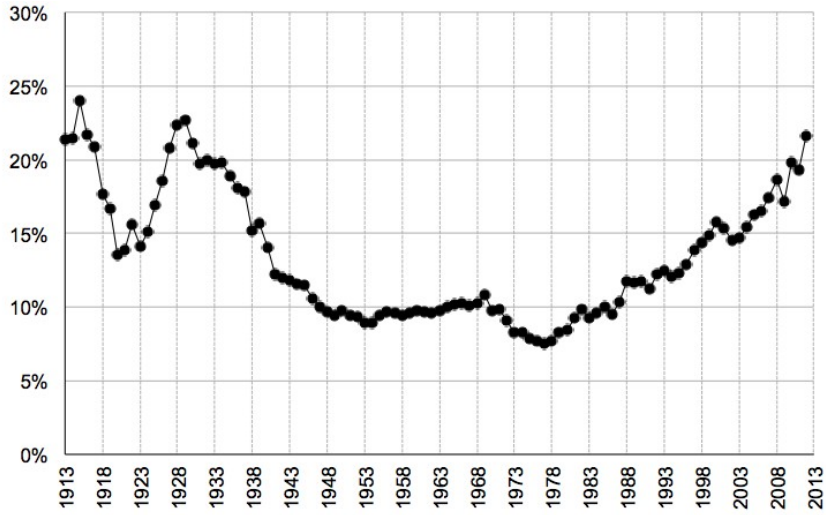

Figure 2: Top 0.1 % wealth share in the United States, 1913-2012 (Saez and Zucman 2014, p. 49)

Figure 2 depicts the evolution of the share of wealth going to the top 0.1% in the United States. Starting from a very high level at the beginning of the past century, the share shrank considerably with the 1929 Great Depression and the two World Wars. It then started to rise rapidly since 1980, and has today reached pre-war levels.

Saez and Zucman (2014) also performed a study about the distribution of households' wealth, defined as current market value of all financial and non-financial assets owned by households net of all their debts [4], in the US since 1913 based on income tax returns data together with flow of funds data. They use the capitalization method on incomes reported by taxpayers, in order to take into account assets that do not generate taxable income. The distribution of wealth in US in 2012 looks as follows: the bottom 90 % own a share of total wealth of 22.8 %; the next 9 % hold a share of 35.4 %; the top 1 % owns 42 % of total wealth; the top 0.1 % holds 22 % of total wealth, as much as the bottom 90 %. This distribution is the result of a U-shaped evolution of top wealth shares in the last century, as we can see in Figure 2, that depicts the trend for the top 0.1 %.

[4]The definition includes for example pension wealth, but excludes human capital, wealth produced by non-profit organizations, because of the difficulty of attributing it to specific families, and consumer durables.

The top 10 % has evolved in a similar way: after a peak of 84% in the 1920s, it was of 63 % in the 1980s, then rising up to 77.2 % in 2012, with this rise being mainly due to the increase of the wealth of the very rich. The top 0.1 % wealth share was indeed about 63 % at the beginning of the century, steadily falling until the end of the 1970s, then rising again from around 7 % in 1979 to 22 % in 2012, almost reaching the 1929 levels.

On the contrary, the bottom 90 % wealth share first increased from 20 % in the 1920s to 35 % in the mid-1980s, driven by the accumulation of housing wealth and pension wealth, and then steadily declined down to 23 % in 2012. Moreover, the bottom half of the distribution always owns close to zero net wealth, such that the share of the bottom 90% is the same as the one owned by top 50-90% families. Net housing wealth of the bottom 90 % accounted for about 15% of total household wealth in the period 1950s-1980s, while now for 5-6%, due to a rise in debts (mortgages, students loans, credit card). On aggregate, household debt indeed increased from the equivalent of 75% of national income in the mid-1980s to 135% of national income in 2009, and it is close to 110% of national income in 2012.

Share of different groups in total capital	Low inequality (never observed; ideal society?)	Medium inequality (≈ Scandinavia, 1970s–1980s)	Medium–high inequality (≈ Europe 2010)	High inequality (≈ US 2010)	Very high inequality (≈ Europe 1910)
The top 10% "upper class"	30%	50%	60%	70%	90%
Including the top 1% ("dominant class")	10%	20%	25%	35%	50%
Including the next 9% ("well-to-do class")	20%	30%	35%	35%	40%
The middle 40% ("middle class")	45%	40%	35%	25%	5%
The bottom 50% ("lower class")	25%	10%	5%	5%	5%
Corresponding Gini coefficient (synthetic inequality index)	0.33	0.58	0.67	0.73	0.85

Table 1: Inequality of capital ownership across time and space (Piketty 2014, p. 248)

Table 1, taken from Piketty (2014), presents some examples of different degrees of capital ownership inequality, ranging from a never-observed low inequality society to a very high inequality context, as the one Piketty sees as a plausible one if the trend continues as nowadays. Having a look at the realized examples, we can compare medium-inequality societies, as the Scandinavian ones in the 1970s and 1980s to medium-high European societies in 2010, and the high-inequality economy of United States in 2010 for what concerns wealth. The differences are

remarkable.

A phenomenon worth mentioning is that the age composition of the wealth distribution has changed during the last decades. Wealth held by families in which the head of the family is aged 65 or more has slightly increased, but little compared to the rise in the fraction of elderly families in the total population, which was from 18% in 1960 to 25% in 2010. The top 0.1% of the wealth distribution is getting younger, maybe partly due to a rise in large inheritances (Piketty, 2014), and their labor income has increased (i. e. compensation of employees, including fringe benefits, together with the labor share of non-corporate profits before tax), making them more able to accumulate fortunes. This is also in line with Saez and Zucman's (2014) analysis that finds that top wealth holders are generally younger today than in the 1960s and earn a higher fraction of total labor income in the economy. From earning slightly less than 0.5% (5 times the average labor income) of all labor income before 1970, top 0.1 % earned a share of 3.1% (31 times the average labor income) in 2012. Considering that they also have much more income from capital, their share of total (labor plus capital) pre-tax income has increased, from about 3% in 1960 to 8% in 2012.

Piketty claims that the very high concentration of capital is explained mainly by the importance of inherited wealth and its cumulative effects: for example, it is easier to save if you inherit an apartment and do not have to pay rent. The fact that the return on capital often takes on extreme values also plays a significant role in this dynamic process. Inheritance is indeed gaining increasing importance: in France, for example, the annual flow of inheritance was about 20-25% of national income between 1820 and 1910, it became then 5% in 1950, and was back to 15% in 2010 (Piketty, 2011).

Inheritance matters in the analysis of wealth distribution since intergenerational transfers account for at least 50 - 60% of total wealth accumulation (Gale and Scholz, 1994) in the US, and it is potentially an important transmission channel of wealth inequality across generations. These considerations are consistent with the fact that wealth mobility is quite static. In fact, Hurst et al. (1998), using the Panel Study of Income Dynamics (PSID) data to analyze wealth mobility between 1984 and 1994, document that most of the mobility occurs in the

mid-range deciles, while the top and bottom ones show high persistence.

Furthermore, an important factor explaining the wealth dynamics is that the saving rate of wealthy people is high (De Nardi, 2015). Many dynamic models used for quantitative policy evaluation, based on the Bewley model, in which people save to self-insure against idiosyncratic shocks, imply that once households get rich, they dissave. In these models, precautionary savings are the key force driving wealth concentration. This implies that when households get sufficiently rich their saving rate decreases and then turns negative.

De Nardi points out that these models are not able to generate the degree of wealth concentration that is observed in the data. In fact, available data for US suggest that rich people save at high rates, explaining the emergence and persistence of large fortunes. Also Saez and Zucman (2014) find that saving rates tend to rise with wealth, as the bottom 90 percent in the wealth distribution save on average 3 percent of their income, whereas the next 9 percent save 15 percent and the top 1 percent save 20-25 percent of their income.

2.3 Income inequality

Income can be defined as the flow of money going to the factors of production, labor and capital, in a given period of time, generally a year. This section, first analyzes income inequalities in general, and then focuses on each component of income, capital and labor, more in depth.

An empirical regularity Piketty finds in his book is that inequality with respect to capital is always greater than inequality with respect to labor. Piketty finds it in all countries in all periods for which he has available data. The upper 10 percent of the labor income distribution generally receives 25-30 percent of total labor income, while the top 10 percent of the capital income distribution always own at least 50 percent of all capital. Moreover, the bottom 50 percent of the labor income distribution receive between one-quarter and one-third of total labor income, whereas the bottom 50 percent of the wealth distribution in many cases own nothing at all, in some cases almost nothing. For Piketty (2014), as capital income is more unequally distributed than labor income, a transfer from labor income to capital income will increase overall inequality.

Maybe the first serious statistical attempt to analyze income distribution was made by Simon Kuznets, who focused on United States in the period 1913-1948. He worked on historical series of income distribution based on two main data sources: US federal income tax returns and his own estimates of US national income. The data were reporting a sharp reduction in US income inequality in the period, with a share of annual national income going to the upper decile declining from 45-50 percent in 1913 to 30-35 percent in the late 1940s.

This analysis gave birth to his inverted U-shaped theory of inequality for which inequality could be expected to follow a "bell curve" over the course of industrialization, increasing in the first phases, since only a small part of the population has the possibility to benefit from the new wealth industrialization brings, while automatically decreasing later on, as a progressively larger fraction of the population benefits from economic growth. The basic problem with Kuznets' work is that it focuses mainly on labor income, while at least for what concerns top shares, it is crucial to take into account both capital and labor income, and their interaction (Atkinson et al., 2011).

Piketty shows that the two World Wars, and the public policies that followed from them, played a central role in reducing inequalities in the twentieth century. In France physical destructions were huge. About one-third of the capital stock was destroyed during the First World War and about two-thirds during the Second World War. The UK lost much of its capital income from abroad during the wars (Atkinson et al., 2011). Corporate taxes rose and restrictions on the payment of dividends were imposed during the wars. There was nothing natural or spontaneous about this process, in contrast to the optimistic predictions of Kuznets' theory.

Another mechanism that was at work in the 1940s was the so-called "Great Compression" in the US wage structure, with a relatively egalitarian wage distribution (Goldin and Margo, 1992). Piketty shows that inequality began to rise sharply again since the 1970s and 1980s, with significant variation between countries, suggesting that institutional and political differences played a key role. Indeed, political variables may be relevant for explaining differences across countries, reflecting political climate and traditions. Roine and Waldenström (2010)

draw a distinction between liberal (Anglo-Saxon) welfare states, corporatist-conservative (continental European) welfare states, and social democratic (Scandinavian) welfare states, that may be influential on the development of inequality.

Income inequality is the result of inequality of income from labor and inequality of income from capital. The relation between these two is another decisive factor for the total inequality in the society. The greater the correlation between capital and income of a person is, the greater is total inequality. In traditional societies the correlation between the two inequalities was often negative, because the more you owned, the less you needed to work, getting almost nothing of labor income. In modern societies the correlation is usually positive but never perfect (Piketty, 2014).

As labor income generally accounts for two-thirds to three-quarters of total national income, inequality of total income is closer to inequality of labor income than of capital income. The top decile of the total income distribution got about 25 percent of national income in the most egalitarian economies in Scandinavian countries in the 1970s and 1980s, whereas in the more inegalitarian societies, as the case of the United States today, the top decile receives about 50 percent of national income (Piketty, 2014). All distributions Piketty presents are before taxes. Depending on whether the tax system is progressive or regressive, the after-tax distribution may be more or less egalitarian. In general, however, net inequality has risen in the OECD over the past decades, as redistribution has not kept pace with the rise in market inequality (OECD, 2011).

Following Piketty's reasoning, there exists mainly two ways of getting to the situation of a society with a highly unequal distribution of total income: through a "society of rentiers", in which inherited wealth plays a crucial role and where wealth concentration is extreme, typical of the French Ancien Régime and the Belle Époque in Europe; through a "society of superstars", in which people belonging to the very top of the income hierarchy are located there thanks to very high incomes from labor, as recently appears to happen in the United States. These two types of inequalities can coexist and usually both forces are at work in each society.

Following the evolution of inequality in the last century, two major phenomena

strike: the reduction of inequality due to the shocks in the period 1914-1945 of the two World Wars and the increase in inequality since the 1970s that has followed different paths in different countries, suggesting that politics and institutions may again have played a crucial role.

Focusing on Europe and US, some examples taken from Atkinson et al. (2011) on the evolution of the top 1% share, starting from the post-war period, are hereby reported. Germany has not witnessed any significant change, as the top 1% claimed 11.6% of total national income in 1949, while in 2005 it got 11.1%, and the same yields for Sweden and France but at lower levels, respectively around 6-7% and 8-9%. United Kingdom's top 1% saw its share rise significantly from 11.47 to 14.25 in the period. The same yields for Norway, but at lower levels, indeed from 8.88 to 11.82%. In United States the increase was extreme, from 10.95% in 1949 to 17.42% in 2005. For Spain and Italy the data are incomplete. For what concerns the period 1919-1949, top incomes were much lower in 1949 than in 1919 in the great majority of countries.

Piketty (2014) reports that, overall, in the last century inequality of total income in France has dropped, as the top 10 percent of the total income distribution owned 45-50 percent just before World War I, while it claims 30-35 percent today. This compression is almost totally due to diminished top incomes from capital, such that focusing on wage distribution the level of inequality has remained pretty stable. Kuznets' theory fails as no structural process have operated. It was war that compressed inequalities, destroying large amount of capital owned by the "rentiers", together with the Great Depression and new public policies, which led to a sharp drop of the capital/income ratio between 1914 and 1945.

Today the top of the income distribution is constituted by "supermanagers", or more in general by people who live on their highly paid salaries. The first 9 percent of the top decile mainly rely on income from labor today, while in the top 1 percent capital income increasingly becomes the main source of income. Furthermore, a very large share of capital belonging to the upper decile is in form of dividends and interest from mobile capital, such that large fortunes are primarily made of financial assets.

For instance, in Italy the increase in top income shares since the mid 1980s

were mainly driven by top wages and self-employment income. In 1976, earnings accounted for less than 10 percent of the income of the top 0.01 percent, but by 2004 it had increased to over 20 percent (Alvaredo, Pisano, 2010). Similarly, in Spain earnings accounted for less than 20 percent for the top 0.01 percent in 1981, while it had doubled by 2004 (Atkinson et al. 2011).

Income inequality in France between 1945 and 1967 rose with the share owned by the top 10 percent increasing from 30 to 37 percent approximately (Piketty, 2014). It then faced a consistent decrease until 1983, with the top decile share going back to 30 percent, finally increasing again, with the top decile share reaching 33 percent in the period 2000-2010.

Inequality tends to evolve procyclically, as during booms the share of profits tend to increase and top wages usually increase more than bottom and middle wages. In France, the purchasing power of the minimum wage increased by more than 130 percent between 1968 and 1983, resulting in a reduction of wage inequalities, as the mean wage increased by only about 50 percent in the same period. In 1982-1983 the government turned toward austerity and no more annual boosts of the minimum wage were undertaken. Wage inequalities increased, as did income inequalities. Top wages increased considerably.

To make another example, United States became more inegalitarian than France and more in general Europe, even if it was a more egalitarian country at the beginning of the twentieth century. US inequality is now as "bad" as in Europe in 1900. Income inequality increased during the 1920s, reaching its peak in 1929, with the top decile getting more than 50 percent of total income. In the following period, with the Great Depression and WWII the trend in the evolution of income inequality was reversed, and inequality decreased substantially, even if less than in Europe. Between 1950 and 1980 the top decile got 30-35 percent of total income, so inequality was relatively low. The eighties opened the doors for the explosion of inequality in the United States. The fraction of national income going to the top 10 percent increased from 30-35 percent in the 1970s to 45-50 percent in the 2000s. Furthermore, this increase in the top 10 percent share is likely underestimated because of tax evasion. The upper decile reached and slightly overcame 50 percent in 2008 and again in the early 2010s.

This increase is partly due to capital gains which were especially very high during the Internet bubble in 2000 and 2007, but Piketty, in his analysis, shows that excluding capital gains, the same evolution of income inequality in US emerges, with the top decile rising from 32 percent in the 1970s to 46 percent in 2010. With inequality being procyclical, after the stock market crash, inequality grew more slowly as in the years 2008-2009 there were not many profits to be taken on the stock market. The long run trend did however not change (Piketty, 2014).

Interestingly, even inside this top decile, the 15 percent increase in national income going to it was not divided equally. In fact, 11 points of this increase went to the top 1 percent, of which half went to the top 0.1 percent. In particular, the increase in wage inequalities and the emergence of "supersalaries" were at the bottom of the increase in income inequality. Furthermore, one third of the increase in income inequality in the US since the 1980s is ascribed to growing capital income inequality.

Share of different groups in total income (labor + capital)	Low inequality (≈ Scandinavia, 1970s–1980s)	Medium inequality (≈ Europe 2010)	High inequality (≈ US 2010, Europe 1910)	Very high inequality (≈ US 2030?)
The top 10% ("upper class")	25%	35%	50%	60%
Including the top 1% ("dominant class")	7%	10%	20%	25%
Including the next 9% ("well-to-do class")	18%	25%	30%	35%
The middle 40% ("middle class")	45%	40%	30%	25%
The bottom 50% ("lower class")	30%	25%	20%	15%
Corresponding Gini coefficient (synthetic inequality index)	0.26	0.36	0.49	0.58

Table 2: Inequality of total income (labor and capital) across time and space (Piketty 2014, p. 249)

Table 2 gives some examples of societies characterized by different degrees of total income inequality. Scandinavian countries in the 1970s and 1980s are the ones with the lowest level of inequality observed in the last one hundred years. Europe in 2010 is characterized by a situation of medium inequality, while the US in 2010 together with European societies in 1910 are considered as high-inequality countries. Furthermore, in Piketty's possible scenario in 2030, if the development of inequalities will follow the same path of the last decades, the US could become even more unequal, with the upper class claiming 60 percent of total national income and the bottom 50 percent getting only a share of 15 percent of total

income.

2.3.1 Capital income

Income from capital includes all income derived from the ownership of capital, i.e. rents, dividends, interests, royalties, profits, capital gains, etc.

Bengtsson and Waldenström (2015), using an historical cross-country dataset on capital shares in 19 countries and data from the World Wealth and Income Database, find a very steep decrease in the capital share in income at the end of WWI for most countries in their analysis. Furthermore, they find a decreasing capital share in the 1950s-1970s in most countries and a reverted trend after 1980, supporting also Piketty's account of the long-run trends in the capital-labor income distribution. In Figure 3 capital shares in income for advanced countries since 1975 are reported (Piketty, 2014). Capital income is 15-25 percent of national income in the 1970s, whereas it is between 25 and 30 percent in 2000-2010.

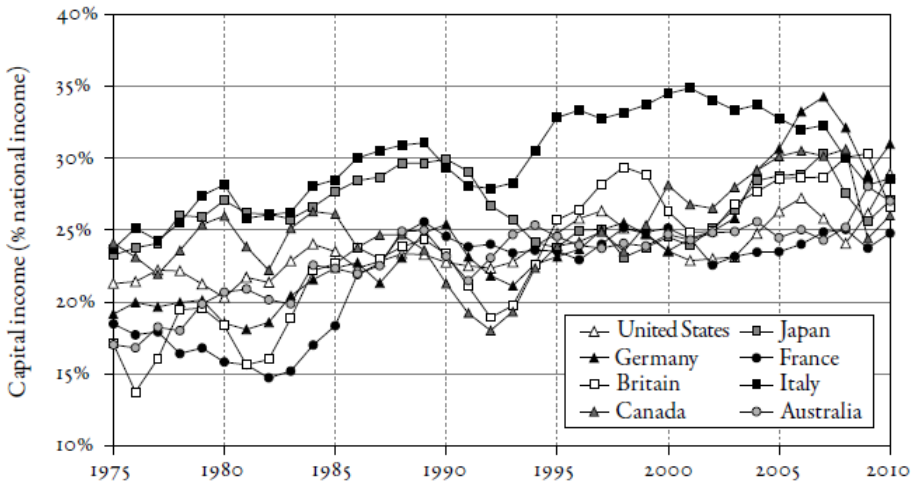

Figure 3: The capital share in rich countries, 1975-2010. Piketty (2014), p. 222

The decline of top capital incomes was the main driving force of the falls in top income shares in the beginning of the twentieth century in most advanced countries. For instance, in the period between 1916 and 1939, 50 percent of US top 1 percent income was constituted by capital income, while between 1987 and 2010 the share fell to a third (Piketty and Saez, 2006). An analogous evolution can be found in the UK, where the share of capital income in the top 1 percent

income fell from 60 percent in 1937 to under 20 percent by the end of the twentieth century (Atkinson, 2007).

One has, however, to be cautious in comparing these figures, as these studies rely on tax data. While it was previously common in France and in the UK to impute rents to homeowners in the income tax base, these imputations are excluded nowadays. As mentioned in the methodological chapter, some elements of capital income, such as interest income or returns on pension funds, are in many cases either taxed separately at flat rates or exempted. For these reasons, the share of capital income that is included in income tax returns has decreased over time (Atkinson et al., 2011). Furthermore, such excluded capital income is generally earned disproportionally by top income groups, such that this exclusion leads to an underestimation of top income shares (Atkinson et al., 2011).

In the case of France, the huge destructions over the period going from 1914 to 1945 implied that capital incomes were not able to recover from the shocks, also due to progressive income and inheritance taxation introduced in the subsequent period (Atkinson et al., 2011). Indeed, progressive taxation hinder the re-accumulation of large wealth, resulting in more equal distribution of capital income.

A similar analysis has been carried out by Moriguchi and Saez (2006) for Japan. Capital income fell dramatically during the Second World War, and the more recent surge of top incomes was mainly due to the rise of top earnings. For the case of Italy, there was only a modest increase in the share of the top 1 percent, from 7 percent around 1975 to 9 percent in 2004 (Alvaredo ad Pisano, 2010). The data show that the share of capital income halved in the period, while the role of wage income increased. However, in the Nordic countries capital income still plays a crucial role, as explained in Roine and Waldenström (2010) for Sweden. For Finland, Jäntti et al.(2010) report that the main driving factor for the rise of the top 1 percent since the mid 1990s is a huge increase in the fraction of capital income. Also in the UK, after the fall of capital income in the first three-quarters of the twentieth century, there has been a partial restoration of capital incomes since the end of the 1970s (Atkinson et al., 2011).

Piketty and Zucman (2014) estimates show that, while new savings explain

the largest part (72 %) of national wealth accumulation in the US between 1970 and 2010, the residual part (28 %) is explained by capital gains. They also estimate that, on average, about 40 % of the rise in the capital-income ratio since the 1970s is due to capital gains.

Inequality of income from capital may be a powerful multiplier of inequality if individuals with large wealth manage to obtain higher returns from their fortunes. For Piketty (2014) this is a plausible scenario for several reasons. First, wealthy people have the possibility to employ wealth management consultants and financial advisors, in order to identify the best investments to undertake. Moreover, it is easier to take risks and to be patient if you have a large reserve than if you own almost nothing. These mechanisms could also explain why the largest fortunes have grown at very high rates in the last decades, significantly higher than the average growth rate of wealth.

The rise of finance since the 1970s-1980s gave the possibility to achieve higher returns from capital ownership and, thus, a faster rate of capital accumulation (Franzini and Pianta, 2016). The banking regulations introduced after the Great Depression became less and less stringent, free international movements of capital were allowed, and the introduction of new financial activities resulted in a huge potential for growing asset values and short-term speculations. The rise of top incomes is, in fact, not only due to higher compensations, but also due to larger profits and capital gains from financial and real estate assets. In fact, about half of the income of the top 1 percent constitutes non-labor income, while for the top 10 percent, 30 percent of the income is capital income (Dabla-Norris et al., 2015).

2.3.2 Labor income

Income from labor generally accounts for two-thirds or three-quarters of national income (Piketty, 2014). The distribution of income from labor takes quite different forms depending on the country, suggesting that national differences and policies may have a central role in shaping the living conditions of the population of a country. This section first analyzes the evolution of the labor share in the main advanced countries, and it then looks at the inequalities in the distribution

of labor income.

The International Labour Organization (ILO, 2015) reports data about the dynamics of labor shares in advanced countries. As late as in 1991 the labor share of total national income was between 59 % in France and Australia and 66 % in UK and Japan, while in 2013 it fell below 60 % everywhere except in UK, and it shrinked to 55 % in Italy and Australia. In particular, the labor share in Spain fell from 57 to 48 % between 1991 and 2013, experiencing a loss of 7 % after 2009. ILO finds the falling labor share being the result of greater profits within industries, especially for what concerns financial services and medium-high technology, more than representing a shift in the sectoral composition towards more capital-intensive sectors.

While the stability of the labor share of income is usually a key foundation in macroeconomic models [5], these empirical evidences show the opposite. Also Karabarbounis and Neiman (2014) document a declining labor income share since the 1980s, this time attributed to firms shifting away from labor toward capital due to efficiency gains in capital-producing sectors, often coming along with advances in computer and information technology. In their analysis, the labor share is computed using a data set of 59 countries in at least 15 years between 1975 and 2012 created by the authors combining country-specific data with sector-level national income accounting data from multilateral organizations. They focus on the labor share within the corporate sector. Out of the 59 countries in the data set, 42 showed a downward trend in their labor shares.

Figure 4 shows the estimated decline in the labor shares in countries included in their dataset, in particular in most major economies in the world. Trend coefficients are reported in units per 10 years, meaning that a value of -5, for example, indicates a 5 percentage point decline every 10 years.

Lin and Tomaskovic-Devey (2013), using time-series cross-section data at the industry level, find that financialization, indicating an increase of the size and importance of a country's financial sector relative to its overall economy, could be responsible for more than half of the decline in labor's share of income. They also

[5] Cobb-Douglas functions used in Solow (1957) and many macroeconomic models after that assumes the stability of the factor shares. This is also true in Kaldor (1961). More on this in the theoretical chapter.

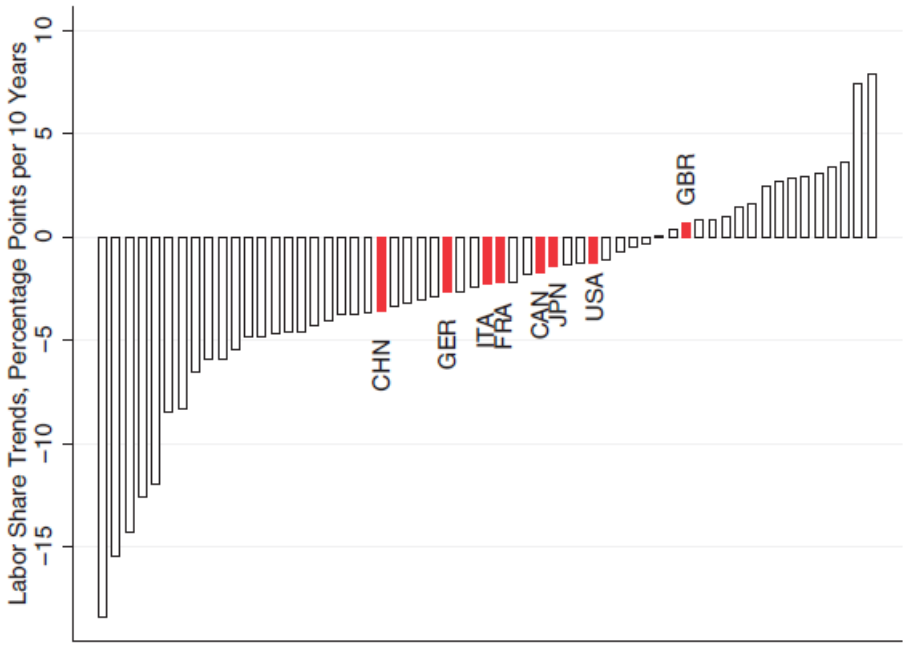

Figure 4: Estimated trends in country labor shares (Karabarbounis and Neiman 2014, p. 73)

find that financialization could be responsible for 9.6 % of the growth in officers' share of compensation, and 10.2% of the growth in earnings dispersion between 1970 and 2008. An increasing focus on the generation of earnings through financial channels, separated the generation of surplus from production, strengthening managers' bargaining power.

Conventional explanations are usually deunionization, globalization, and technological change. The decline in unionization and other labor market institutions is one of the explaining factors for the observed income dynamics studied by economists. Kristal (2010) finds evidence for a positive association between union density and labor share of national income among developed countries. Globalization, with global flows of capital, goods, and labor, would reduce the bargaining power of low-skilled workers in high-wage countries. In the technological change explanation, the spread of information technology since the 1980s increased the output of physical capital and the demand for skilled workers, leading to technology-driven changes in marginal productivity. This theory, however, fails to explain why the fall in the labor share is larger in Europe than in the US. More on these explaining factors in the next chapters.

Figure 5 shows how the top decile, starting from high levels at the beginning of

the twentieth century, decreased its share of income after the two World Wars in all countries until the 1970s or 1980s, when it then started to rise rapidly again to high levels. From this graph one can appreciate that, even if the increase has been pronounced also in Sweden, there are big differences between the Scandinavian country and the United States. The top decile in the US gained an increasing income share in the last decades, reaching and almost overcoming in 2010 pre-war levels. This is explained in Piketty as due to the rise of the supermanagers, meaning the huge increase in compensations to the top management of firms. This new category of extremely high labor income earners is a phenomenon that is emerging in the last two or three decades.

In past decades, individuals belonging to the richest part of the population mostly earned their income from capital and rents. In the last thirty years the labor income of the very rich appears to have increased with the extremely high salaries earned by top managers and professionals in sport and show business (Atkinson et al., 2011). This phenomenon seems to define a sort of "winner takes it all" economy (Frank and Cook, 1995), in which few highly skilled individuals can cover a large part of the demand. This theory comes from Rosen (1981), for which the expansion of scale associated with globalization and with increased communication opportunities, also thanks to recent IT developments, has raised the rents of those with the very highest abilities.

However, the evidence about skill-biased technical change being the cause of rising wage inequality is weak (Card and Di Nardo, 2002) and, as argued in Piketty (2014), there is a widespread practice among managers in corporations to set their own pay, which tends to overestimate their skills and performance. This is possible because of the power that top managers have inside firms.

Strikingly, among the top 350 US firms, the ratio of compensation given to managers to that of the average employee rose from 30 to 1 in 1978 to 296 to 1 in 2013. To appreciate how big this difference is, one can note that the US President earns only 25 times the wage of the worst paid federal employee (Mishel and Davis, 2014).

This is a factor that depresses the picture even more: not only the labor share in national income is decreasing, but this labor share is also earned to an

increasing extent by the wealthiest part of the population.

Figure 5 depicts the evolution of top deciles income shares for different countries in the period 1900-2010 [6]. We can see that European countries have had a less extreme development of inequalities with respect to United States. While European countries started from a highly concentrated labor share in the hands of the top decile, with a share of around 45% going to this part of the population, they have not reached these levels again yet, even if the rise since the 1980s has been impressive. United States started with a share of 40% of national income going to the top 10%, and it has now overcome pre-wars levels, reaching almost 50%.

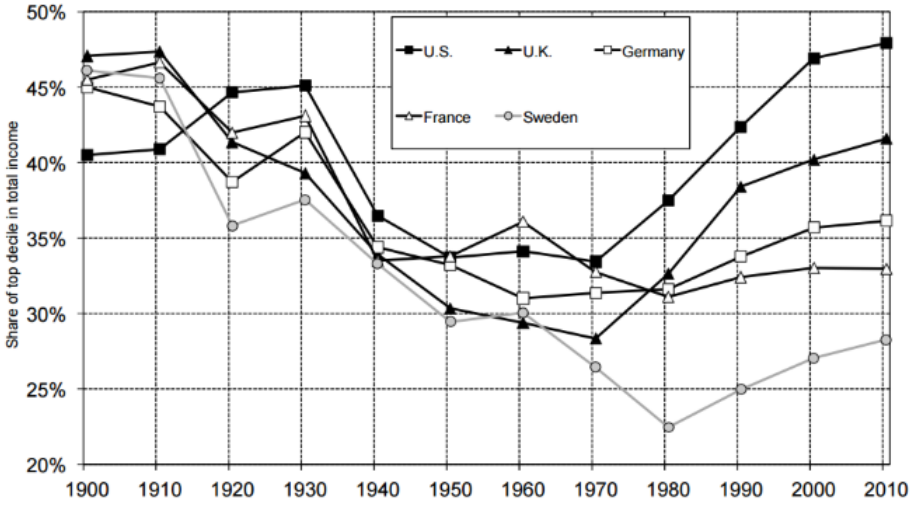

Figure 5: Top decile income share in US and Europe, 1900-2010 (Piketty 2014, p. 323)

The two main phenomena that have been at work in recent decades are the increase in the wage gap between college graduates and those who stop their educational career at high school (Goldin and Katz, 2008), together with the take-off of the remuneration to the top 1 percent, as mentioned before. Piketty (2014) estimates that this second phenomenon, in particular the increase in compensations for the top centile, explains almost three-quarters of the increase in the top decile's share of US national income since 1970.

Table 3 is useful to compare different examples of labor income inequalities. The relatively most egalitarian societies are again Scandinavian countries

[6]Since labor income corresponds to three-quarters of total income, this picture is representative of the evolution of labor income distribution.

Share of different groups in total labor income	Low inequality (≈ Scandinavia, 1970s–1980s)	Medium inequality (≈ Europe 2010)	High inequality (≈ US 2010)	Very high inequality (≈ US 2030?)
The top 10% ("upper class")	20%	25%	35%	45%
Including the top 1% ("dominant class")	5%	7%	12%	17%
Including the next 9% ("well-to-do class")	15%	18%	23%	28%
The middle 40% ("middle class")	45%	45%	40%	35%
The bottom 50% ("lower class")	35%	30%	25%	20%
Corresponding Gini coefficient (synthetic inequality index)	0.19	0.26	0.36	0.46

Table 3: Inequality of labor income across time and space (Piketty 2014, p. 247)

in the 1970s and 1980s, as for capital income, while the least egalitarian is US in 2010. Piketty (2014) finds that in the most egalitarian societies the distribution is roughly as follows for the population: the 10 percent receiving the highest incomes from labor claim a little more than 20 percent of the total income from labor; the least well paid 50 percent get about 35 percent of the total; and the 40 percent in the middle receive roughly 45 percent of the total income from labor. For the US, in 2010 the situation is quite different, with the top 10 percent claiming around 35 percent of total labor income, the middle 40 percent claiming 40 percent, and the bottom 50 percent of the distribution receiving only 25 percent of the total.

The divergence among developed countries is surprising for mainstream economics, as technological change has been the same more or less everywhere: in particular, the revolution in information technology has affected Japan, Germany, France, Sweden, and Denmark as much as the United States, Britain, and Canada. Furthermore, growth in GDP per capita has been quite similar in the countries considered in the last decades (Piketty, 2014). The theory of marginal productivity and of the race between technology and education does therefore not seem able to explain these phenomena. This theory builds on the assumption that a worker's wage is equal to its marginal productivity, which depends on his skills and on the supply and demand of these skills in the labor market. The more a skill is required, and the less it's available, the higher the remuneration given to workers having that skill, with respect to ordinary workers, the higher the wage inequality. When technological progress occurs, demand of particular skills increases. Workers whose training and skills are not sufficiently advanced will earn less and wage inequality will increase.

The educational system must be able to supply with updated skills to an increasing number of workers in order to avoid increasing inequality. Goldin and Katz (2008) claim that increasing inequality in the US is due to insufficient investments in education, such that people didn't receive a proper training, also due to high tuition costs. Following this reasoning, the best way to prevent increasing wage inequality would be to invest in education, as also Piketty suggests in his book. This theory, however, fails to explain why wage inequality is different in different countries. Even if many advanced countries are very similar in terms of technological development, inequality may indeed differ a lot. This suggest that other mechanisms have to be taken into account.

Institutions and rules in the labor market are other factors that may play an important role. As a striking example, the minimum wage in the United States, in terms of purchasing power, reached its maximum of 1.60 dollars an hour (10.10 dollars in 2013 dollars, taking into account inflation) in 1969, with the unemployment rate being lower than 4 percent at that time (Piketty, 2014). The purchasing power given by the minimum wage then decreased under Reagan and Bush in the eighties, rose under the presidency of Clinton, was constant under Bush and has been increased several times by Obama. Income inequality at the bottom has closely followed this evolution of the minimum wage, while top income inequality, as for example the share of wages going to the top 10 percent, has continuously risen.

Kristal and Cohen (2016) find evidence for the fact that the decline of unionization and of the real minimum wage are responsible for 50 - 60% of the increase in the US wage inequality in the period 1969-2012. Jaumotte and Buitron (2015) find that the erosion of labor market institutions is associated with growing income inequality, as also Dosi et al. (2016) find. The decline in unionization is correlated to the rise in top income shares and less redistribution, whereas the decrease in minimum wages is associated with increases in inequality. They also find a correlation between financial deregulation and higher inequality and lower top marginal tax rates and higher inequality.

The marginalistic theory is not even able to take into account the explosion of top incomes. The rise of top incomes is a phenomenon that mainly occurred

in Great Britain, US, Canada and Australia. It thus cannot be explained by the theory of technology and education but must be due to some other institutional factors.

Piketty in his book presents a theory of why this explosion occurred, especially in the United States. Speaking about marginal productivity of top managers gives not much sense to the discussion, since every time the tasks performed are different and unique. Salaries are usually set by their superiors or at the very highest levels by themselves. Since the contribution of each manager's work to the firm's output is a vague concept and almost impossible to estimate, this wage-setting process becomes arbitrary and heavily depends on the bargaining power of the individuals involved. So, in the limits of corporate governance rules in the society, executives tend to be generous in setting their own compensations, or at least optimistic in estimating their marginal productivity.

Social norms and acceptability become also important. A very high remuneration is more shocking in France than in US for example. Incentives of top executives to set higher pays with respect to the past were promoted by the very large decrease in the top marginal income tax rate in Anglo-Saxon countries in the 1980s. This cut led to the explosion of top incomes, which in turns increased significantly top managers' influence in political decisions and in tax setting itself, having an interest in keeping top tax rates low or even decreasing them further. Having the possibility to finance political parties and pressure groups may increase the top's political power significantly.

Furthermore, another interesting aspect of labor income inequality is the degree of intergenerational income mobility in a country. The International Monetary Fund (IMF, 2014) reports that intergenerational earnings mobility, defined as the elasticity between a parent's and child's earnings, is lower in countries with higher income inequality, such as US, UK and Italy, while it is much higher in the more egalitarian Scandinavian countries. In the former group of countries, about 50 percent of any economic advantage that a father has is passed to his child, while for the latter countries the transmitted advantages are only 20 percent. This correlation between inequality and intergenerational mobility is called the "Great Gatsby Curve" (Krueger, 2012), and it is referred in the literature as

inequality of opportunity.

2.4 Inequality, macroeconomic dynamics and growth

Now that I have analyzed how inequality has evolved over time in its different components, I will introduce a sample of studies performed by different scholars on the links between inequality, macroeconomic stability and growth. Starting with the econometric analysis carried out by Maestri and Roventini (2012), what they find is a positive correlation between inequality and unemployment in Canada, Sweden and the US. Most inequality series are, in fact, counter-cyclical, positively correlated with unemployment. Furthermore they find that consumption inequality is pro-cyclical in US and UK. This can be explained by the increasing debt taken up by low-income households, who try to keep constant their level of consumption during crisis. They also perform some causality tests that suggest that an increase in inequality may be conducive to recessions. Unemployment seems also to be granger-caused by inequality.

Atkinson and Morelli (2011) find that while some crises were preceded by rising inequality, some other were not, and they are in any case cautious about establishing causality in cases where such a rise took place. However, their analysis does not investigate whether the level of inequality was relatively higher before periods of crisis, so they do not exclude this hypothesis. They find more robust evidence about rising inequality after financial crises, in particular after a hiatus during the crisis, probably due to a solid welfare state and fiscal policies, in the three banking crises of the late 1980s and early 1990s in the Nordic countries (Sweden, Finland and Norway), and in the crises during the same decade in Japan and Italy.

Kumhof and Rancière (2010) point out that in the United States, the Great Depression, which started in 1929, and the Great Recession, which started in 2007, were both preceded by a sharp increase in income and wealth inequality and by a rapid rise in debt-to-income ratios among lower and middle income households. Based on this empirical observations, Fitoussi and Saraceno (2010), Stiglitz (2012) and Fitoussi (2013) argue that the roots of the recent crisis, which emerged in the financial sector, lie in a structural change in income distribution

that has been occurring in the last thirty years. These theories will be presented in more details in the theoretical chapter. Cynamon and Fazzari (2013) note that in the same years in which income disparities widened, the American economy performed reasonably well with sustained consumption spending and an average annual growth rate of 3.16% between 1981 and 2007; on the contrary, continental Europe, experienced excess savings and sluggish growth. The reason why increased inequality led to excess savings in some areas, while resulting in excesses demand in others, lies in the interaction of the trend in income distribution with institutional differences, in particular the degree of financialisation, and the different policy responses. They claim that the development of financial markets seems to be a key factor in explaining differences among countries.

Other economists as well argue that increasing inequality is indeed at the root of the Great Recession. Even if the income share of the top 5% increased from 22% in 1983 to 34% in 2007 (Kumhof and Rancière 2010) and the top 1% of the population in the US doubled its share in national income from around 8% in the mid-1970s to almost 16% in the early 2000s (Milanovic, 2010), analogously to the period prior to the 1929 crisis, the US economy performed well in the years before the crisis, apparently giving no obvious signs about the fact that something was going wrong. Since the rich usually have a lower propensity to consume than the poor, one would expect a reduced consumer demand leading to unemployment and lower growth. Instead, American households increased their spending relative to income from 81% to 95% (Cynamon and Fazzari, 2013). This can be explained by the increase in household debt from 48% of GDP in the early 1980s to 100% of GDP before the crisis (Milanovic, 2010). Prior to the crisis, this relationship between inequality and financial instability was never included in economic studies, neither was the link between inequality and the risk of crisis (Galbraith 2012, Atkinson and Morelli 2011). In fact, DSGE models generally assume that the representative agent always satisfies the transversality condition, removing any default risk (Goodhart, 2009).

While there seems to be clear evidence about the sustained consumption of low-income households that occurred prior to the recent crisis, it can also be important to document how households behave in the aftermath of a crisis. Krueger,

Mitman and Perri (2016) provide evidence for the importance of household heterogeneity for macroeconomic questions, employing the Panel Survey of Income Dynamics (PSID) dataset for the US in some years before and after the Great Recession. They find that wealth is a highly concentrated variable and that differences in consumption rates across wealth quintiles are significant. For instance, these differences between the bottom and top quintiles range between 20% and 30%. They conclude that these differences across groups can have an important role for the aggregate consumption response to a macroeconomic shock. In fact, they find that, after the Great Recession, the decline in the growth rate of consumption expenditures is most pronounced at the bottom of the wealth distribution, and conclude that the bottom of the distribution is crucial in understanding macroeconomic dynamics.

We have seen how inequality can affect macroeconomic stability and the emergence of crisis. Turning now to the correlation between inequality and long-run growth, we will see that the evidence is mixed. The empirical evidence is divided between those studies that find a positive correlation between the variables, and more recent studies which find the correlation to be negative.

In the last 30 years, the belief that reducing inequality would be bad for growth has been dominant. One of the typical arguments in defence of this thesis is that rich people save more than poor people, such that income concentration leads to higher savings which in turn may finance higher investments, overall leading to higher growth. This argument is based on Kaldor's (1957) hypothesis that the marginal propensity to save of rich people is higher than that of poor people. Then if the investment rate is positively related to the saving rate, and growth is positively related to investment, more unequal economies can be expected to grow faster. For example, Bourguignon (1981) shows that with a convex saving function, aggregate output depends on the initial distribution of income, and is higher the more unequal the society is. Concerning poor countries, Barro (2000) claim that some degree of inequality allows at least a few individuals to gather the minimum needed to get educated and to start businesses.

Furthermore, inequality is seen as the result of higher rewards given to those who perform better, as a natural product of capitalism. In fact, for some scholars,

inequality would enhance growth because it provides incentives for innovation and entrepreneurship (Lazear and Rosen, 1981), and attempts to remedy inequality would reduce those incentives, harming growth.

Using a panel data approach, a study by Forbes (2000) found evidence for the fact that an increase in inequality tended to raise growth during the subsequent five-year period. Benerjee and Duflo (2003), in their analysis, claim that changes in inequality in either direction lower growth in the subsequent five years through the channel of redistributive policies which according to them hurt growth. I will in next section analyze more in depth this channel.

The literature on the relationship between inequality and growth also stresses the importance of initial conditions on the level and growth of per capita income (Durlauf and Quah, 1999). In line with this, Benhabib (2003) detected a nonlinear relationship between inequality and growth, such that increasing inequality from low levels would stimulate growth, while an increase past some point of inequality would engender rent-seeking and lower growth.

The other stream of literature is represented by those studies that find inequality to be harmful for growth. Atkinson (2015) states that the hypothesis for which inequality would help growth is not proven and that there is no general link identified. Several studies have, in fact, recently found that high inequality may be destructive to growth, by amplifying the risk of crisis or making it difficult for the poor to invest in education. One of this is the report by OECD (2015), which provides evidence for inequality having a negative impact on growth through the channel of human capital: the wider the income inequality, the lower the chance that low-income households invest in education, harming growth.

Another example of analysis claiming that inequality is detrimental for growth is the one carried out by Benabou (1996), who, arrives to this conclusion summarizing a number of papers that deal with the causal effect of inequality on growth or investment. In fact, the main result from 23 recent studies is that a one-standard-deviation decrease in inequality raises the annual growth rate of GDP per capita by 0.5 to 0.8 percentage points.

Also Herzer and Vollmer (2012) find a negative long-run effect of income inequality on per-capita income for 46 countries, using data over the period 1970-

1995. Voitchovsky (2005) underlies the importance of the shape of the income distribution as determinant of economic growth, as inequality at the top end of the distribution is positively correlated with growth, while inequality at the bottom of the distribution is negatively correlated with subsequent growth.

Moreover, Berg and Ostry (2011) and Ostry et al. (2014), from the IMF, find evidence for lower net inequality being robustly correlated with faster and more durable growth for a given level of redistribution. Income inequality seems to be a strong predictor of growth duration, more than many variables widely understood to be central to growth, as good political institutions and increases in human capital. It is important to point out that these studies analyze correlations, so that firm statements about causality are hard to make, as Atems and Jones (2015) argue. For example, there are some cases in history in which extreme equality did not conduct to strong growth. In their paper, using a panel vector autoregressive model, they claim that in the medium run, initial inequality has a positive impact on the level of per capita income; however, the effect turns and stays negative after some periods. In fact, when they estimate the long-run response of per capita income to an initial inequality shock, the response is negative and persistent. Overall, they conclude that increases in income inequality, whatever measure for inequality they use, leads to lower income per capita.

Also Dabla-Norris et al. (2015), still from the IMF, argue that higher inequality lowers growth by preventing lower-income households to stay healthy and accumulate physical and human capital. Labor productivity can therefore be lower than in a more egalitarian society, also in line with Stiglitz (2012). Furthermore, increasing concentration of incomes can reduce aggregate demand, damaging growth, as the marginal propensity to consume of the wealthy is generally lower than the one related to middle- and lower-income groups. Furthermore inequality may dampen investments, and hence growth, by being responsible for a higher degree of economic, financial and political instability. Inequality could also lead to policies that may hurt growth, as for example a limited provision of public goods, together with the fact that growth is less efficient in lowering poverty in countries characterized by high levels of inequality. Using a panel on 100 countries over the period 1980-2012, they also find that financial globaliza-

tion, technological progress and an increase in the skill premium are associated with an increase in the top 10 percent disposable income share.

2.5 Inequality, redistributive policies and growth

Before presenting some studies analyzing the possible links between redistributive policies and growth, I will briefly discuss how redistributive policies may affect the income distribution in the first place. Atkinson et al. (2011) summarize the main channels through which marginal tax rates can affect the earning distribution. Higher top marginal tax rates can reduce top reported earnings through the supply side channel, i. e. that workers can work less and earn less; through the tax-shifting channel, for which top earners may substitute cash compensation with other forms of non-taxable compensation, as fringe benefits, deferred stock-option or pension compensation, in order to avoid tax; finally, high top taxes may lower incentives to extract higher compensation. In many studies [7], there is evidence for the fact that top marginal tax rates seem to negatively affect top income shares, but causality is difficult to assess.

Roine and Waldenström (2010) find that progressive taxation seems to have been a major contributing factor in the explanation of the evolution of incomes in Sweden after the two World Wars, preventing the accumulation of new fortunes. Similarly, Jäntti et al. (2010) claim that in Finland the reduction of income tax progressivity since the mid-1990s is crucial in explaining the rise of the top income share in the country. However, Saez and Veall (2005) suggest that in the case of Canada tax changes cannot be the sole cause, and Canadian top income changes are more strongly associated with similar changes in the US, suggesting the presence of international forces, than with the national tax modifications. Alvaredo (2010) points out that in Portugal, even if tax rates have kept constant for a certain period, top shares have continued to rise. A possible issue may be the timing of the impact changes in tax rates may have on top shares, as Atkinson et al. (2011) note.

Since the early 1980s, the progressivity of the tax systems and the tax burden on businesses has substantially decreased in all major developed countries.

[7] See Saez (2004), Atkinson and Leigh (2007), Roine, Vlachos and Waldenström (2009).

		1981	1991	2001	2008
Belgium	Number of Brackets	23	7	7	5
	Maximum Rate	72%	55%	55%	50%
France	Number of Brackets	12	12	6	4
	Maximum Rate	60%	56.80%	52.75%	40%
Germany	Number of Brackets	2	2	2	2
	Maximum Rate	56%	53%	48.50%	45%
Italy	Number of Brackets	32	7	5	5
	Maximum Rate	72%	50%	45%	43%
Spain	Number of Brackets	30	16	6	4
	Maximum Rate	65.1%	56%	39.6%	27.1%
Ireland	Number of Brackets	5	3	2	2
	Maximum Rate	60%	52%	42%	41%
UK	Number of Brackets	6	2	3	2
	Maximum Rate	60%	40%	40%	40%
US	Number of Brackets	16	2	5	5
	Maximum Rate	70%	31%	39.10%	35%

Figure 6: Number of tax brackets and marginal income tax rates for a sample of European countries and US, 1981-2008 (Fitoussi and Saraceno 2010, p. 5)

Fitoussi and Saraceno (2010) present the results summarized in Figure 6. It can be noted that both the marginal income tax rates (referring to central government rates) and the tax brackets, i.e. the number of divisions at which tax rates change, have decreased in all countries, suggesting a reduction in the degree of progressivity in the tax system. This decrease in the marginal income tax rate has, however, been different in magnitude in the countries considered. While for France it decreased from 60% in 1981 to 40% in 2008, in the United States it halved in the period. For Alvaredo et al. (2013) these different patterns in the decrease of marginal top taxes can be one of the explanations for the evolution of inequality in the countries. Even if France and US have experienced more or less the same technological advances, inequality in US has increased much more than in France in the last decades. Alvaredo et al. (2013) indeed find that there is a strong negative correlation between the reductions in top tax rates and the increases in top 1 percent pretax income shares. They also claim that these tax cuts may have changed the bargaining power and may have induced managers to increase their remuneration at the expense of enterprise growth and employment.

Redistributive policies effects on growth is a debated topic among scholars. In

particular, some economists believe redistribution distorts incentives and does not allow the economy to achieve efficiency, while some others find that redistribution positively affects growth through reduced income inequality.

Mainstream economics suggests that the significant and widespread reduction in top tax rates experienced in the last decades enhances incentives to investment and hence increases employment. Similarly, in neoclassical growth models taxing capital reduces the return to saving, inducing people to increase consumption and reduce savings, which lowers investments and growth. In an analogous way, other policies as minimum wage, labor market regulation, trade and capital restrictions affect expected profits and induce capital holders to reduce investments (Persson and Tabellini 1994, Alesina and Rodrik 1994). In this perspective, inequality may induce the choice to undertake redistributive policies, hence harm growth. For instance, in these models inequality may harm growth because it may lead to government intervention. Also subsidies given to low-income households for orthodox economics would reduce wage disparities, increasing unemployment. The increase in unemployment would occur because of the lack of downward wage flexibility implied by this wage compression.

Another economist who advocated a negative effect of redistributive policies on growth is Okun (1975), whose theory assumes a trade-off between efficiency and equity. For this reason, efforts to reduce inequality leads to efficiency "leaks". Tanzi and Zee (1997), find some general indication that the relationship between growth and the level of total taxes or of income taxes is negative but that this relationship is not robust and is sensitive to model specification.

The other category of studies in the debate about the impact of redistributive policies on macroeconomic dynamics posits that redistribution has a positive impact on macroeconomic stability and growth. Dosi et al. (2016), reject Okun's law, finding that equality and efficiency are highly correlated in their analysis performed with an agent-based model. A larger fraction of unemployed workers indeed increases the level of personal income inequality. Furthermore, more unequal income distribution and higher unemployment spells both induce a stagnant evolution of aggregate income. These considerations are confirmed in empirical studies which find redistributive policies to lead both to the reduction of inequal-

ities and to the enhancement of growth. In fact, Ostry et al. (2014) identify some win-win policies that could promote both efficiency and equity, as spending on public capital or education. Also Benabou (2000,2002) and Bleaney, Gemmell, Kreller (2001) claim that some categories of public spending as public investments in infrastructure, health, education, social insurance provision are both pro-growth and pro-equality. These studies all reject Okun's law.

While mainstream economists focus on the incentives to invest resulting from marginal tax cuts, another stream of literature has based its analysis on the fact that marginal tax reductions induce a shift of the burden of taxation from capital income to wages, the former accruing in a larger proportion to the richest part of the population. Atkinson (2015) present some very strong evidences about the fact that not only tax reductions for the rich have had negative effects on inequality, but they also failed to sustain investment and growth. Piketty et al. (2011) find that countries that made large cuts in top tax rates, such as the United Kingdom or the United States, have not grown significantly faster than countries that did not, such as Germany or Denmark.

Using several measures of redistribution (marginal tax rates, average tax rates, social spending), Easterly and Rebelo (1993) find that redistribution is likely to have a positive impact on growth. Similarly, Perotti (1996) tests whether income inequality has an impact on the marginal tax rate, and whether the latter affects growth. His results suggest that while inequality may play no role in setting the marginal tax rate, higher marginal tax rates will have a positive impact on growth.

Also Ostry et al. (2014) find that redistribution appears to have positive effects on growth. Only for extreme levels of redistribution there is some evidence that it may have direct negative effects on growth. In particular, when redistribution is already high (above the 75th percentile), there is evidence that a further increase in redistributive policies may be harmful to growth, whereas when it is below that level, there is no evidence for any effect on growth. Overall, redistribution has a pro-growth effect, counting both for potential negative direct effects and positive effects of resulting lower inequality. Moreover, for very large redistributions they find that the point estimate related to the effect of redistribution

on growth is larger in absolute value than the estimated effect of inequality on growth, but the difference is not statistically significant. So even for large levels of redistribution the evidence is weak. The data tend therefore to reject Okun's assumption that there is a trade-off between redistribution and growth.

Dabla-Norris et al. (2015) suggest that fiscal policy plays a critical role in ensuring macrofinancial stability and can thus help prevent or minimize crises that disproportionately hurt the disadvantaged part of the population. At the same time, fiscal redistribution can help raise the income share of the poor and middle class, and thus support growth. Also Stiglitz (2009) claims that "when the economy gets weaker, spending on social protection and unemployment schemes should automatically go up, helping to stabilize the economy. However, at least in the United States and some other countries, one of the sad facts of the so-called reforms in recent decades is that we have been weakening these important automatic stabilizers." (Stiglitz, 2009, p. 4).

3 Theoretical background

In this section I will summarize the main theoretical standpoints about inequality and distribution of income encountered in the history of economic thought. Following the classification of theories presented by Kaldor (1955), one can distinguish among four main schools of thought: the Ricardian or Classical Theory, the Marxian, the Neo-Classical or Marginalist Theory and the Keynesian and Post-Keynesian. At the end of the section, I will also present some more recent neoclassical models, which identify some attempts made by mainstream economics to include distributional issues in macroeconomic analysis. Finally, in Section 3.3, Piketty's standpoint about the theory of distribution is presented, together with some theories which attempt to explain how inequality may be a decisive factor for the understanding of the Great Recession.

3.1 Inequality in the history of economic thought

The first considerations about the distribution of income can be traced back to Malthus and Young at the very end of the eighteenth century, who believed that welfare assistance to the poor was not justified and that reproduction by the poor was a severe threat for the overpopulation, leading to chaos and misery. Ricardo (1810), exponent of the Classical Theory, shared with Malthus and Young this view of the long-run evolution of the distribution of wealth and class structure of society. He believed landowners would inevitably claim an increasing share of output and income. Having no statistics at his disposal, he constructed a theory based on the scarcity of land: when both output and population grow steadily, land tends to be relatively more scarce with respect to other goods, such that its price will continuously rise, following the laws of demand and supply, and the landlords will get increasingly high rents. The social equilibrium will thus be upset, since the majority of the population will get a lower and lower share of total output. The solution he proposed was a steadily increasing tax on land rents.

As Ricardo couldn't foresee the importance technological progress and industrial growth would have, his predictions turned out to be wrong. Land rents kept

high for a period, but the value of farm land then declined considerably relative to other forms of wealth (Piketty, 2014). Anyway, what can be interesting to draw from this "scarcity principle" is a reflection on how big increases in prices of some goods can influence the distribution of wealth and destabilize economic, social and political systems. More recently one can think about dramatic changes in the price of oil and real estate as examples of such dynamics. While the usual laws of supply and demand would imply a lower demand of the good whose price has increased, this mechanism can take time, and in the meanwhile allow a small elite, as oil producers, to accumulate wealth.

For Marx (1867) industrial capitalists were the ones who claimed an increasing share of income. Until the final third of the nineteenth century, workers' wages stagnated at very low levels, while the capital share of national income (profits, land rents, building rents) was increasing in Britain and France (Piketty, 2014). The capitalists were the owners of industrial capital (machinery, plants, etc.), which in principle could be accumulated without limit (on the contrary, Ricardo's analysis builds upon the limited availability of the amount of land). Marx's theory is indeed based on the "principle of infinite accumulation", i.e. the tendency for capital to accumulate and be concentrated in fewer and fewer hands with no natural limit to the process. He believed that the conflict would be either among capitalists, in the case the rate of return would steadily diminish, or between capitalists and workers, if capital's share of national income would continue to increase. The result would in any case be the end of capitalism.

Even if its prophecy did not realize, as wages increased in the end of the nineteenth century, what we can learn from his theory is that if the growth rates of population and productivity are low, the accumulation of wealth becomes increasingly important and possibly socially destabilizing. In Japan and in the wealthy countries of Europe, since the 1980s and 1990s, private wealth has indeed reached very high levels, as reported by Piketty (2014).

For neoclassical economic theory, income distribution was not an issue because it was determined by the technology. Assuming, for example, a Cobb-Douglas production function, the marginal productivities of capital and labor determined respectively the interest rate and the wage, shaping the distribution, with one

part of the cake going to profits and capital, and the other part going to labor and so to workers. The distribution is, thus, determined by technology and there is no room for public policy.

Another school of thought is the one related to Keynesian and Post-Keynesian economics. Although Keynes didn't directly focus on the topic of distribution, these theories apply Keynes' apparatus of thought to the problem of distribution.

Keynes recognized that an economy with a highly unequal wealth and income distribution could create difficulties in maintaining full employment. His motivation was that the richer people are, the more of their income they save, and there is a growing gap between consumption and production, together with the fact that the richer a society grows, the fewer new investment opportunities there are. In fact, for Keynes savings do not always find an outlet in productive investment, preventing full employment (Keynes, 1936).

The first remedy Keynes suggested was that the government could increase its public expenditure taking up loans. With the socialization of investment, the investment returns would fall. Another possibility would be to achieve the so called "euthanasia of the rentier", using monetary policy and lowering the long-run rate of interest. In fact, the rentiers had for him a parasitic function in the society, as they didn't make any sacrifices for obtaining this income, but similarly to landlords with rents, interests were just a reward for owning a scarce resource. Another expedient he suggested was a redistribution of wealth and income toward the part of the population with the highest propensity to consume, the poor.

Keynes justified some degree of inequality, seeing it as an incentive for productive activity and as a channel for competitive impulses. However, he thought that existing inequalities were excessive, and that it would be desirable to reduce them. His motive for wanting to eliminate excessive inequality and unemployment was, to a great extent, that he viewed them as threats to capitalism, and feared revolutionary responses. This problem could be solved enlarging the role of the government, in his view.

Among Post-Keynesians, Kalecki (1939, 1942, 1954) and Kaldor (1956) contributed to the study of income distribution. For Kalecki the rate of profits of the capitalist depends on the investment rate, so, given that they have access to

credit, the more they invest, the more they make profits. As for Kalecki workers' marginal propensity to save is basically zero, this group just spend what they earn. Kaldor (1956, p. 96) indeed citing Kalecki writes that "capitalists earn what they spend, and workers spend what they earn". In a Kaleckian framework, mark-ups which determine profits, depend on the degree of monopoly, so they are a function of the degree of competition in the production, in addition to the cost of raw materials. A combined increase of these two factors reduce the wage share. Kalecki observed that between 1880 and 1913, the wage share had not witnessed important changes because of the stability of both the degree of monopoly and of raw materials' prices. However, in the period 1913-1935 raw material prices decreased significantly with respect to wages. Observing no significant change in the wage share, Kalecki deduced that the degree of monopoly must have increased (Kalecki, 1939). In his theory the mark-up is countercyclical, as it increases in recessions, in order to increase profits, and decreases during booms, as unions become stronger. Raw material prices are determined by demand and are therefore procyclical. These two mechanisms counterbalance each other, explaining the constancy of the wage share in the short term.

Kaldor's work implies that the increase in inequality triggers a redistribution from households with high propensity to consume, the poor, to households with a lower propensity to consume, the rich, and, similarly, from credit-constrained households to households without such constraint. The increase of inequality generates, thus, a chronic deficiency of aggregate demand, and a tendency of growth to stagnate. Furthermore, while Goodwin (1967) assumed that a higher wage share leads to lower investment and thus a general economic downturn, Kalecki (1971) argued that a higher wage share would have an expansionary effect because the consumption propensity out of wage income is higher than that out of profit income.

For decades the majority of economists have almost been silent about distributional issues, with the predominance of Kuznets theory and its optimism, for which inequality would decrease once capitalism had developed to an advanced phase. A similar optimism can be found in Solow's 1956 analysis: when the economy achieves a balanced growth path, all variables grow at the same pace, so that

every social group benefits from growth to the same degree. This mainly stems from the Cobb-Douglas assumptions of constant shares of labor and capital in income that, with the Solow model, was transferred directly from microeconomics to macroeconomics. These reasonings have led to decades of omittance of the theme of inequality in most research.

3.2 Neoclassical models

Some recent neoclassical models in the literature have tried to take into account market imperfections, linking them to the study of inequality. I will hereby present a sample of such models. Two main streams of literature have been in place in the "modern paradigm". The first is the capital markets imperfections approach, introduced by Galor an Zeira (1993), for which in presence of credit markets imperfections, in sufficiently advanced economies, equality stimulates investments in human capital for the majority of people and stimulates growth. Another approach, more political economy-oriented, claims that equality diminishes the risks for socio-political instability, or for distortionary redistribution, enhancing investments and growth.

For Galor (2000) the classical approach, which assumes saving rates as increasing function of wealth, and for which inequality therefore channels resources towards individuals whose marginal propensity to save is higher, increasing aggregate savings and capital accumulation, resembles early stages of economic development, when physical capital is considered as the prime engine for growth, while more advanced economies face mechanisms similar to the ones studied in the credit markets imperfections approach, where human capital accumulation is a fundamental source of growth.

Another example of model taking into account capital markets imperfections is the one in Aghion, Banerjee and Piketty (1999). They build a macroeconomic model in which endogenous and permanent fluctuations in GDP are indeed generated by imperfections in the capital markets and unequal access to investments. In presence of decreasing returns with respect to individual capital investments and credit market imperfections, meaning that individual investments are an increasing function of initial endowments, then inequality concentrates investments

in the hands of few people and prevents growth. In order to achieve macroeconomic stabilization, a reduction of inequalities may be necessary in this framework. Moreover, in the model, savings are underutilized in recessions because of limited debt capacity of potential investors. The government should perform countercyclical fiscal policies, issuing public debt to finance investment subsidies or cut taxes for investors.

Inequality may also have an influence on short-term output volatility. Heathcote and Perri (2015) develop a microfounded dynamic equilibrium model in which economic fluctuations are driven by fluctuations in household optimism or pessimism. They use a representative household and a representative firm. The model predicts that volatility depends on the level of household wealth. When wealth is high, unemployment expectations doesn't affect consumer demand, and the economy is robust to confidence crises. When wealth is low, they argue a precautionary way of reasoning takes place and unemployment expectations affect more demand, making the economy more vulnerable to confidence-driven fluctuations. Indeed, from the Survey of Consumer Finances (SCF) for the period 1989-2013, they observe that median real net worth since 2007 has halved, showing no signs of recovery through 2013. In this case, public policies may have a stabilizing role with respect to consumer demand. They also evaluate some policies to counterbalance the decline in demand that can fuel a recession, as a lump-sum unemployment benefit, financed by a tax on workers, which turns out to reduce the sensitivity of demand to the expected unemployment rate. In their model, higher government spending, however, turns out to be an uneffective policy.

Some recent DSGE models allow for some form of agent heterogeneity among agents building on Krusell and Smith (1998), as for example Eggertsson and Krugman (2012), where agents are split between patient or impatient agents, and in Kumhof and Rancière (2010) and Kumhof et al. (2015), where agents are divided between top earners and bottom earners. For example, Kumhof and Rancière (2010) build a theoretical DSGE model linking inequality, household debt and financial crises. Their analysis is concentrated on how changes in the income distribution can trigger high leverage and crises. Empirically, they observe

that the periods 1920–1929 and 1983–2008 both exhibited a large increase in the income share of the rich, a large increase in leverage for the remainder, and an eventual financial and real crisis. In their model top earner households (5% of the income distribution) lend to the bottom ones (95% of the income distribution). An exogenous inequality shock induces low-income households to increase their indebtedness, raising their rational willingness to default and the probability of a financial crisis.

The introduction of two types of agents allow DSGE models to explore new issues such as inequality. Also financial frictions are introduced in some models (starting with Bernanke et al., 1999), where borrowers have different access to the financial markets. Heterogenenity in these cases is, however, given by pre-determined categories, without accounting for interactions. They apply adjustements to the surface of models, without considering deep real implications (Fagiolo and Roventini, 2016).

Recently, the importance of heterogeneity in the study of macroeconomic dynamics has been underlined by Krueger, Mitman and Perri (2016). Extending the Krusell and Smith (1998) real business cycle model, they find that wealth inequality can significantly amplify the impact of an aggregate downturn. In fact, the decline in consumption of the wealth-poor households, as a result of a shock, imply a larger fall in consumption and output (when it is considered to be partially demand-driven) than considered in the standard representative agent version. This is particularly true in the case in which a large fraction of households with little wealth increase their savings after the shock. Moreover, in this model, households having high propensity to save, not only save for precautionary motives, but also for retirement purposes, such that even at high wealth levels they do not start to decumulate, in line with the empirical findings of De Nardi (2015). In this way the model, differently from the one in Krusell and Smith, is able to replicate a distribution of wealth which is similar to the current one in the US, even if not as skewed at the very top.

3.3 Piketty and recent theories on inequality and macroeconomic dynamics

Only recently the problem of distribution has gained an increasing attention. Among others, Piketty underlines the political nature of the distribution of wealth and points out how any determinism in the study of inequality, as the one suggested by Kuznets, should be avoided, since its dynamics cannot be reduced to purely economic mechanism. In fact, the reduction in inequality that was experienced by most countries in the period 1910-1950 was mainly a consequence of war and policies to recover from the shocks connected to it. In the same way, it was a political shift in the determination of taxation and financial deregulation which led to rising inequality after 1980 (Piketty, 2014). Views about what is just and what is not, and the relative economic and political power of actors have presumably a remarkable weight in shaping the dynamics of inequality over time.

In Piketty's analysis, an important role in shaping the mechanisms behind inequality is played by the power top managers and other people belonging to the highest percentiles of the income distribution can have in deciding their compensation. This phenomenon is particularly seen in the United States and to some extent in the United Kingdom. Even more importantly, weak growth and high returns on capital are two destabilizing and threatening factors to an equal distribution of wealth over the long run. He theorizes that when the rate of return on capital is higher than the growth rate of the economy, inherited wealth grows faster than earned wealth, leading to the accumulation of resources in the hands of an increasingly smaller part of the population. Furthermore, the saving rate may increase sharply with wealth, as opposed to what is assumed in standard models, and the rate of return on capital may be a function of initial capital endowment, such that people with higher capital endowments are able to gain more than others from their accumulated wealth. These are typical forces of divergence, which appears to be increasingly common nowadays. Piketty's point is that in slowly growing economies, past wealth becomes increasingly important. Furthermore, if the rate of return on capital is higher than the growth rate for a period of time, then there is a high risk of divergence in the distribution of

wealth.

In his view, the rise of the capital share, defined as the share of profits in income, is the result of the high rate of return to capital and of the increase of the capital/income ratio. Moreover, the rising capital/income ratio is seen as the result of a stable propensity to save and a slowdown in income growth due to stagnating population and slow increases in productivity. When the inequality $r > g$ is satisfied, where r stands for the average annual rate of return on capital, including profits, dividends, interest, rents, and other income from capital, expressed as a percentage of its total value, and g is the growth rate of the economy, meaning the annual increase in income, inherited wealth grows faster than output and income. Inherited wealth will thus dominate wealth accumulated due to labor income savings, and the concentration of capital will reach extremely high levels. Moreover, in Piketty's framework some reinforcing mechanisms may take place, as for example a higher average effective return on capital whose owners have higher capital endowments, together with the "scarcity principle" applied to real estate or petroleum [8].

For Piketty, when wealth accumulates and concentrates, with the implication that inheritance ends up mattering more than hard work, the consequence is the formation of a rentier society more than a meritocratic society.

Some authors, Fitoussi and Saraceno (2010), Stiglitz (2012) and Fitoussi (2013) , have underlined how this structural change in income and wealth distribution that has been occurring in the last thirty years are at the roots of the recent crisis, which emerged in the financial sector. In fact, they find in the widespread increase of inequality the cause of a depressed aggregate demand. Building on Kaldor's (1955) framework, when inequality rises, resources are transferred from low-income households to high-income households, from those who consume almost all of their income to those who have a high propensity to save, causing a reduction in the average propensity to consume. Savings increase and aggregate demand goes down. Monetary policy reacted by maintaining the level of the interest rate low. This allowed private debt to increase beyond sustainable levels. In fact, in this framework, growing income disparities force low and middle

[8]For critics on Piketty's analysis see Franzini and Pianta (2016), Acemoglu and Robinson (2015), Jones (2015), Kopczuk (2015).

income households to enter credit markets so as to find the external resources that are needed to satisfy consumption needs. Moreover, lower interest rates and higher house prices allow for relaxed collateral constraints and, therefore, higher credit availability.

This extremely active borrowing undermines the stability of the system: a growing number of households defaults on their debt obligations, and, ultimately, the credit bubble explodes and the structural vulnerability of the economy emerges. The bubble emerged also due to a continuous search of high-return investments by those at the top of the income distribution. "Net wealth became overvalued, and high asset prices gave the false impression that high levels of debt were sustainable. The crisis revealed itself when the bubbles exploded, and net wealth returned to normal level."(Fitoussi and Saraceno (2010), p.2). This process led to a severe tightening of credit conditions, which constituted the main channel for the transmission of the crisis to the real sector, and with it a generalized decrease in aggregate demand. For these reasons, their major suspects for the causes of the crisis are the lax monetary policy preceding it, together with the deregulation of financial markets and the increase in inequalities that depressed aggregate demand.

Stiglitz (2012) also explains that monetary policy is used in response to a lower demand, instead of fiscal policy, for political reasons. Growing inequality leads to more and more weight to the wealthiests' influence in political decisions, as also Piketty argues. This part of the population is usually in favour of a smaller government and lower fiscal action. So inequality and constraints in the government's fiscal space go hand in hand.

Stiglitz (2012) and Rajan (2010) indeed underline the role of political-economy factors, as the influence of the rich in allowing financial excess to explode on the eve of a crisis. They claim that the recent crisis was the result of a set of political and economic pressures that led high-income individuals to save, low-income people to keep a certain level of consumption through borrowing, and financial institutions to encourage the process. In this environment, lobbyists were allowed to push for financial deregulation (Acemoglu, 2011).

4 Agent-based models, inequality and crises

In this section I will motivate why I choose to use an agent-based model for the study of inequality, and I will make a survey of previous studies concerning inequality, indeed in the field of Agent-Based Computational Economics (ACE), a new paradigm proposed by some scholars, as a reaction to new neoclassical synthesis models, represented mainly by DSGE models. Given the stylized facts presented in Section 2 and the theoretical hypothesis seen in Section 3, it can be argued that traditional economic models do not seem to be able to fully explain the evolution of inequality and its impact on macroeconomic dynamics. It is therefore interesting to use a new approach, namely the ACE approach, that can be able to analyze these phenomena.

As a reaction to the recent crisis, several economists realized that orthodox economics not only didn't forecast the crisis, but it did not even admit the possibility of the occurrence of a crisis (Krugman, 2011). Furthermore no satisfying policy advices to recover from the crisis have been proposed since it occurred (Stiglitz, 2011, 2015). This permitted this relatively new field in economics to gain increasing attention. Stiglitz (2011) underlines how aggregate demand can be affected in fundamental ways by the distribution of income. In fact, with individuals having different marginal propensities to consume, aggregate savings and consumption rates depend on income distribution. He argues that distributional concerns are crucial in interpreting the recent crisis. In fact, growing inequality would have led to lower consumption but, because of low interest rates and little regulations, the story was a different one, as already explained in the previous sections. Therefore, distributional issues should be taken into account in macroeconomic analysis.

While neoclassical models use the representative agent assumption to obtain a stable and unique equilibrium, avoiding any aggregation problems, in order to study inequality, heterogeneity is fundamental. As Fagiolo and Roventini (2016) point out, the representative agent assumption compresses macroeconomic dynamics into microeconomics. Kirman (1992) presents some convincing arguments about why the use of a representative agent is not appropriate for the study of macroeconomic dynamics. One of these is that, even if we assume that individu-

als are well-behaved and utility maximizers, their interactions may not produce a well-behaved maximizing representative agent. Moreover, the reactions of the representative agent to exogenous shocks, may not correspond to how individuals would respond. Finally, the representative individual's preferences may be the opposite of the society's preference as a whole.

The representative-agent assumption, thus, does not make neoclassical models able to account for distributional issues. If the agent looses in terms of reduced wage, for example, the same agent get additional resources in terms of profits. In agent-based models, instead, the economy is considered as a complex evolving system with heterogeneous agents whose interactions shape the dynamics of the system. The result is the emergence of macroeconomic dynamics by microinteractions, with heterogenity having a crucial role in the analysis. As this thesis primarily deals with inequality and its impact on macroeconomic dynamics, taking into account agents with different characteristics, such as income and wealth, seems a natural way of proceeding.

Furthermore, I would like to study the interaction between inequality and fiscal policies. Policies may have different effects on the performance of the economy, depending on which "social class" they are addressed to. Stiglitz (2011), for example, points out that tax cuts for the rich have lower multipliers than unemployment benefits. These considerations come from Keynes, Kaldor and more in general the Post-Keynesian school of thought, which considers marginal propensities to consume which are decreasing in income. The representative agent assumption does not allow to take these aspects into account. Moreover, in DSGE models the effects of both fiscal and monetary policies are time invariant. On the contrary, recent empirical evidence has found that the impact of policies can be different according to non-linearities in the economic system, and so very different for example in times of recession compared to periods of boom. Following this literature, both the state of the economy (see e.g. Auerbach and Gorodnichenko, 2012) and the state of financial markets (Mittnik and Semmler, 2013; Ferraresi et al., 2014) matter. As my analysis also deals with fiscal policies, this varying impact which depends on the state of the economy can be important, and it can be taken into account in an agent-based model. All in all, DSGE models can

perform well in "normal" times, but they are not able to take into account crises and deep recessions (Stiglitz, 2015).

Before presenting a survey of studies on inequality with agent-based modeling, I will hereby summarize the main ingredients of AB models, presented in detail in Fagiolo and Roventini (2016). One of AB models' key ingredients is the bottom-up perspective, meaning that aggregate properties are obtained as emergent dynamics given by interactions, which are usually non-linear, at the micro level. As previously mentioned, heterogeneity is a driver of such interactions. Furthermore, the economy is considered as an evolving complex system, such that interactions among agents repeated in time determine aggregate properties. Interactions among agents are direct and decisions depend on past choices made by other agents, with adaptive expectations. Agents are supposed to be boundedly rational, as opposed to hyper-rationality assumptions used in DSGE models. Agents are able to learn by previous behaviors and the evolution of the state of the system is path-dependent. Novelties are introduced in the system, which generate new patterns of behavior, with agents facing true uncertainty. Finally, selection shape market mechanisms.

The above-mentioned characteristics of agent-based models make them particularly suited to study inequality and fiscal policies. First of all, the possibility to assign agents heterogeneous income shares and the fact that agents can be given different marginal propensities to consume, is crucial in this context. This permits to analyze distributive issues and their effects on macroeconomic dynamics together with the effects of stimulative redistributive policies. Secondly, the fact that interactions among agents generate endogenous dynamics, that continuously shape the economy, can make the analysis richer, with respect to an analysis based on a static economy, which only dynamics stem from exogenous shocks. Moreover, what is interesting is that agents are not utility maximizing agents, which seems quite an unrealistic assumption, but they follow simple rules based on the limited information they have about the economy.

Agent-based modeling permits a very detailed description of the economy under study and can, thus, represent in a more realistic way, with respect to standard models, modern economies. The great flexibility of these models permits

to perform experiments about different inequality scenarios and policy mixes, observing in each case how the economy evolves. In this way, fiscal policies can be evaluated and compared in different scenarios, characterized by different institutional settings. Moreover, since policies may affect the economy in different ways depending on which part of the population they are directed to, as pointed out by Stiglitz (2011), it is important to take into account heterogeneity. This is possible with the use of computer simulations, without the need of a complex solvable mathematical apparatus. In general, since the real world is continuously characterized by out of equilibrium dynamics, in which inequality can play an important role, agent-based models can be particularly suited to incorporate all these issues.

As opposed to neoclassical economics in which micro-foundation consists in assuming that the aggregate behavior is given by the single agent's behavior on a larger scale, in this framework the emergence of properties on the aggregate is more than given by just the sum of its parts. The emergence of complex properties stems from repeated interactions among simple entities (Kirman, 1998). I believe this aspect is crucial in understanding macroeconomic dynamics.

4.1 ABM survey

After the Great Recession an increasing number of ABM have been presented, as policy makers appear to be more willing to believe in results and recommendations obtained by detailed simulation models, with an observable economic structure, instead of relying on a complex mathematical basis as in DSGE models. I will hereby present a sample of these models trying to explain possible causes of the evolution of inequalities, the effects of inequality on macroeconomic dynamics and, finally, the role public policies can have in this framework.

Some papers detect the role institutions have in shaping the evolution of inequality. Isaac (2014) challenges the validity of the overlapping generation model in Blinder (1973), which predicts that family institutions, such as marriage and inheritance, can sustain wealth inequality but not cause it. This model assumes fixed sex ratios in family composition. These predictions discourage attention to family institutions in explaining the dynamics of wealth inequality. Just by

changing the assumption of stable sex ratios with a random sex composition of the family, Isaac proves that these predictions are fragile. He considers two scenarios for what concerns marriage: assortative mating, meaning that the richest male agent marries the richest female and the same for agents lower in the ordered income list, and random mating. For what concerns inheritance he considers the "male-preference bequests" scenario, which means that if the family has only one son, he inherits everything, multiple sons inherit everything and split it equally, and in the absence of a male heir, daughters inherit everything and split it equally. What the model predicts is that male-preference bequests combined with assortative mating causes the emergence of extreme wealth inequality, such that bequest and mating practices appear to be important determinants of economic inequality.

Other institutions which can affect the evolution of inequalities are labor market institutions. Caiani, Russo and Gallegati (2016) find that an effective way to reduce inequalities is a high degree of labor coordination in setting wages. In fact, in their model, greater downward rigidity of wages seems to stop the trend of rising inequality which emerges in all scenarios they analyze. Their conclusion is that recent labor market reforms which aim is a more flexible labor market, and the progressive weakening of collective bargaining have played an important role in the resulting polarization of income and wealth, which has been empirically observed in many advanced countries since the 1980s. Also Dosi et al. find that labor market structural reforms which reduce workers' bargaining power increases both functional income inequality and personal income inequality.

A number of papers in this stream of literature have detected the possible links between inequality and macroeconomic dynamics. Cardaci (2014) builds an agent-based model in order to study the effects of inequality on the likelihood of a crisis and on the stability of the economy. In his model, households compare their level of consumption to those over them in the income scale and to their behavior in the past. This assumption is based on some evidence for this behavioural rule. He finds that as the income share of the top 1% reaches its peak of 46.35%, low and middle income homeowners lack the internal resources to finance desired consumption and there is a decline of aggregate demand that starts a trend of

declining GDP, with the economy entering a recession. After inequality stabilises, the economy gets back on a growing path. In this model, changes in income disparities seem to matter more than the level of inequality itself.

Similar results on the effects of different levels of inequality on the performance of the economy are also found in Dosi et al. (2013). In their framework, more unequal societies suffer from more severe business cycles fluctuations, higher unemployment rates, increasing the likelihood of economic crises. These findings are confirmed in Dosi et al. (2016), where more unequal income distributions, together with periods of high unemployment, worsen macroeconomic conditions and the long run growth of income.

A possible channel through which inequality can affect macroeconomic dynamics is given by the credit conditions in the economy. This is investigated in a number of papers with agent-based models. For example, Cardaci and Saraceno (2015) present an agent-based macroeconomic model with the aim of showing how the effects of rising inequality on the performance of the economy are influenced by the institutional setting and the credit conditions. They find that when there is a low degree of financialisation and banks are less willing to lend, wider inequalities lead to a drop in aggregate demand and output. On the other hand, relaxed credit constraints and a higher willingness to lend, result in a positive effect on growth in the short run, but, at the same time, in greater financial instability and a debt-driven boom and bust cycle. Also Russo et al. (2015) investigate the links between increasing inequality and consumer credit in a context of financial fragility. Introducing consumer credit have contrasting effects, as it boosts aggregate demand, lowering unemployment, but it also accelerates the system's tendency to the crisis. If the rich consume relatively less than the poor, increasing inequality may cause a lack in aggregate demand. This results in lower investments and higher unemployment. Consumer credit may indeed counterbalance this effect for a period, but possibly increasing the likelihood of a crisis because of financial instability. Russo et al. (2015, p. 3) write that "All in all, there seem to be causal links between rising inequality and the expansion of finance, and between unsustainable indebtedness and financial crises. There could be, then, a significant impact of inequality on financial instability and macroe-

conomics dynamics. This is particularly relevant to understanding the causes of the current crisis.". Indeed, they believe that rising inequality could be at the root of the present crisis, as well as the "bad distribution of income" that was one of the major causes of the Great Crash of 1929 and of the Great Depression (Galbraith, 1954).

In Dosi et al. (2015), an heterogeneous banking sector is added to the Dosi et al. (2013) model, supplying credit to firms. In this case, there are two possible effects of inequality on macroeconomic dynamics. When firms' mark-ups are low [9], more firms go bankrupt and this weakens the banking sector, further damaging the supply of credit. More firms are financially constrained and reduces production and investments, leading to increasing unemployment rates. On the other hand, when firms apply high mark-ups, they do not invest due to a low expected demand. This leads to high GDP volatility and high unemployment rates.

Many papers with agent-based models investigate the links between public policies, inequality and macroeconomic dynamics. Dosi et al. (2013) show that fiscal policies dampen business cycles and unemployment, reducing the probability of crises. Moreover, Keynesian fiscal policies, as tax rate and unemployment benefits, have a positive effect on both long-term growth and the dampening of economic fluctuations. Interestingly, more unequal the economy is, the larger the fiscal space and so the greater the effects of fiscal policies.

Also Dosi et al. (2015) analyze the effects of fiscal and monetary policies on macroeconomic dynamics. They find that the best policy mix to stabilize the economy is composed by unconstrained counter-cyclical fiscal policies, dampening business cycles fluctuations, and a dual monetary policy target, including employment. It is interesting to point out that, in this framework, the effects of monetary and fiscal policies are more pronounced when the level of inequality is higher. As a result, also fiscal consolidation policies have a stronger negative effect, the more unequal the economy is.

Caiani, Russo and Gallegati (2016) using an agent-based model with different household classes characterized by different average propensities to save and to

[9] In this model the mark-up denotes the level of inequality in the system. The type of inequality considered is the functional inequality, meaning how output is shared among the factors of production, i.e. capital and labor.

consume, find that progressive taxation lowers income and wealth inequality and spurs prolonged real economic development. They also find that institutional and labor market measures aimed at enhancing collective bargaining and at reducing downward rigidity for low and middle workers, imposing for example a minimum wage, are effective in fostering economic development.

A progressive tax system counterbalances the increasing inequality providing poor households with resources to finance their desired consumption also in Cardaci and Saraceno (2015), who investigate the effects of different policies on the stabilization of the economy. In their model, this effects given by progressive taxation result in a boom in GDP followed by a prolonged period of stability, as the household sector relies less on debt accumulation [10]. For this reason, they believe that it is extremely important to address the problem of inequality at its roots.

[10] Any possible distortionary effect of greater progressivity on labour markets or firm investment decisions are not taken into account.

5 The model

Given the difficulties encountered in standard economic models in taking into account real heterogeneity and deep microinteractions, in order to understand the role inequality has in shaping macroeconomic dynamics, this thesis utilizes and expands an agent-based model presented by Napoletano, Roventini and Gaffard (2015).

The original model is characterized by heterogeneous agents, divided between borrowers and savers, with time-varying financial conditions, and it is aimed at studying how output evolves and how fiscal multipliers change according to the state of the credit market. The authors analyze different fiscal policy regimes. The first one is a deficit-spending rule, in which the government keeps a constant level of public spending and allows a deficit to emerge. Then, two balanced-budget rules are introduced, the first one implying an adjusted tax each year such that, even if the level of government spending is constant, total tax revenues must be equal to public spending, and the second one in which government spending is equal to tax revenues. A bankruptcy shock for a small fraction of the population is introduced. This triggers a series of defaults which increase the non-performing loan or "bad debt" held by the bank. This reduces the bank's net worth and, thus, diminishes the credit supply.

As a consequence, the number of credit-rationed borrowers increases. Aggregate consumption also reduces because a larger fraction of the population is not able to satisfy their consumption plans. This implies that aggregate output goes down, and, therefore, household income falls as well (households' incomes are defined as a share of total income). This dynamics implies that also savers' income falls with respect to their consumption, so that some of them could enter in the pool of borrowers in order to sustain their desired level of consumption. This leads to a situation in which an increasing number of borrowers becomes credit rationed. As a result, aggregate income falls even more.

What the authors find is that the deficit-spending fiscal rule allows a better resilience of the system to the shock, dampening the effect of the shock and lowering its persistence. They also find that the size of the multipliers is time-varying and it is related to the evolution of credit rationing. In a situation in

which a large fraction of households is credit constrained, public expenditure sustains private consumption on the one hand, and, on the other hand, it repairs households' balance sheets, by increasing their wealth and allowing them to return to normal consumption levels. On the contrary, in presence of the two balanced-budget rules, GDP persistently falls below the steady-state level. Multipliers are also lower in these cases.

The research question this thesis would like to answer, using this model, is how different levels of inequality may affect the macroeconomic dynamics of an economy. Furthermore, this work analyzes how the complementarity between fiscal policies and inequality affects the performance of the system in the short-run, in terms of the evolution of aggregate income and other relevant variables. To pursue this investigation, the original model is modified in order to adapt it to this research question. An inequality shock is inserted in the model, as will be explained in more details in this section. In particular, three different shocks are introduced, which generate three different distributions of income in terms of the degree of inequality they represent. Furthermore, in addition to the direct government consumption policy considered in the original model, this version of the model includes the possibility to target public expenditure towards low-income agents, through a subsidy.

In this version of the model, only the deficit-spending fiscal rule is considered. Moreover, a crucial feature of this version is that, after the inequality shock, households that become poorer are characterized by a high effective marginal propensity to consume as they want to maintain the same consumption habits as before. An additional increase in their income would therefore be totally spent until they reach their desired level of consumption. Households which, as a consequence of the inequality shock, are much richer than before spend only a small fraction of their income and, thus, have a lower effective marginal propensity to consume.

This is in line with empirical evidence that finds that households with low income and wealth exhibit a higher marginal propensity to consume than rich households. For example, Jappelli and Pistaferri (2013) perform an analysis based on the 2010 Italian Survey of Household Income and Wealth, and find that the

marginal propensity to consume declines sharply with income and wealth, from around 65% in the lowest percentiles to some 30% for the richest households. These findings are confirmed also in a recent empirical analysis performed by Krueger, Mitman and Perri (2016), finding that differences in consumption rates between the bottom and the top wealth quintiles range between 20% and 30% [11].

One of the main findings of this study is that an inequality shock generates a dynamics of falling aggregate income as a result of an increase in the number of credit-constrained households and a fall in aggregate demand. This is present in every scenario of inequality, with the fall being increasing with the level of inequality introduced in the economy. Moreover, for a given level of inequality, the fall is dampened by higher government expenditure. The multipliers found in this analysis are time-varying and change according to the conditions in the credit market. Furthermore, multipliers seem to be higher in the case of a lower inequality shock, for every fiscal intensity parameter.

The introduction of a subsidy targeted to low-income households dampens the fall in aggregate income in every inequality scenario. Moreover, in every case analyzed, the subsidy is associated to a higher peak multiplier than the corresponding case without subsidy. In other words, the subsidy is more effective than direct government expenditure in sustaining aggregate demand and income and in lowering the fraction of constrained borrowers. In other words, this redistributive policy works as an automatic stabilizer for the economy, in line with McKay and Reis (2016), who find that higher transfers to the unemployed and poor are indeed effective at lowering the volatility of aggregate output.

5.1 Model Setup

In the model there are N heterogeneous agents, owning an amount of wheat, which is purchased by j mills, using it to produce the consumption good with a constant returns to scale technology.

$$Y_{jt} = L_{jt} \tag{1}$$

[11] Consumption rates are measured by computing total consumption expenditures for each wealth quintile and then dividing it by total disposable income.

Total output is simply

$$Y_t = L_t \tag{2}$$

The price the wheat is purchased at is P_l, up to a maximum level of available wheat L^{max}. The firms own zero profits so the price of the consumable good is $P_0 = P_l$. In this model overall consumption demand determines the level of mills' output and thus households income.

Each household has a constant desired level of consumption Z_i such that if $Z_i \leq W_{it}$, where W_{it} is households' i liquid wealth at time t, the household is a saver and her consumption equal to her desired level. Otherwise, if $Z_i > W_{it}$, the household i is a borrower.

In the economy there is a representative bank whose total credit supply is

$$TS_t = kE_t^B \tag{3}$$

where $k > 0$ is the credit multiplier and, since we are in an endogenous money framework (Lavoie, 2003), $k > 1$. Credit supply depends on the bank's net worth at time t, E_t^B, such that the healthier is the bank from a financial viewpoint, the higher is the credit supply in the economy, in line with Basel II and Basel III global regulatory standards (BCBS, 2011). Credit is allocated to agents using a pecking order depending on W_{it}/CD_{it}, where credit demand is given by $CD_{it} = Z_{it} - W_{it}$. If total credit demand is higher than total credit supply some borrowers are partially or totally credit rationed. In the case credit is denied to some agents, their consumption is equal to their current net liquid wealth. Interest rates on loans and deposits are respectively

$$r^b = r(1 + \mu^b) \tag{4}$$

$$r^s = r(1 - \mu^s) \tag{5}$$

where r is the interest rate set by the Central Bank.

Bank liabilities are

$$L_t^B = kE_t^B - E_t^B = (k-1)E_t^B \tag{6}$$

Bank profits are given by

$$\pi_t^B = r_t^b(kE_t^B) - r^s(k-1)E_t^B = [r^s + k(r^b - r^s)]E_t^B \tag{7}$$

If some households go bankrupt, this negatively affects the supply of credit since the bank takes the bad debt.

$$E_t^B = E_{t-1}^B + \pi_t^B - \Sigma_{i=1}^N BD_{it} \tag{8}$$

Bank profits are distributed to the banker if there is no bad debt. Also the banker faces a tax on profits. No distribution of profits occurs if there is some bad debt.

There is a proportional tax on income, such that households' disposable income is given by:

$$y_{it}^D = (1-\tau)y_{it} \tag{9}$$

with $i = 1, ..., N$ and $\tau > 0$ being the tax rate.

Aggregate demand is given by

$$Y_t = AD_t = C_t + G_t + \pi_t^B \tag{10}$$

such that it is defined as the sum of households and government consumption, respectively C_t and G_t, plus the consumption of bankers, π_t^B, if any.

Households' marginal propensity to consume is $\beta_{it} = Z_i/W_{it}$. In particular, if $\beta_{it} > 1$ the household is a borrower, while if $\beta_{it} \leq 1$ the household is a saver.

It is assumed that consumption loans and remuneration of savings must be fully repaid at the end of each period.

The law of motion of agents' wealth is thus

$$W_{it+1} = (1-\tau)y_t - (1+r_b)(\beta_{it} - 1)W_{it} \tag{11}$$

if the agent is a borrower, and

$$W_{it+1} = (1-\tau)y_t + (1+r_s)(1-\beta_{it})W_{it} \tag{12}$$

if the agent is a saver.

Households go bankrupt if they're unable to repay their debt, so if:

$$(1-\tau)y_{it} < (1+r_b)(\beta_{it}-1)W_{it} \tag{13}$$

In terms of consumption levels:

$$(1-\tau)y_{it} < (1+r_b)(C_{it}-W_{it}) \tag{14}$$

If a households goes bankrupt, his wealth is set to zero and the bank gets a credit loss equal to:

$$BD_{it} = (1+r_b)(C_{it}-W_{it}) - (1-\tau)y_{it} \tag{15}$$

At the beginning of each simulation run the economy is in steady state.

Each household is assigned a share of total household income.

$$y_{it} = \alpha_i(1-\tau)Y_t^H \tag{16}$$

where Y_t^H is total household income.

The steady-state level of wealth, considering that in absence of credit-rationing all borrowers are able to satisfy their consumption plans, is

$$w_i^* = \frac{\alpha_i(1-\tau)Y_t^{H*}}{[1-(1+r^b)(1-\beta_i^*)]} \tag{17}$$

if the agent is a borrower, and

$$w_i^* = \frac{\alpha_i(1-\tau)Y_t^{H*}}{[1-(1+r^s)(1-\beta_i^*)]} \tag{18}$$

if the agent is a saver.

Aggregate consumption is stable in steady state and each agent consumes a fraction of total consumption:

$$C_i^* = \gamma_i^* C_i^* \tag{19}$$

where $\Sigma_i^N \gamma_i^* = 1$.

Furthermore, as $C_i^* = \beta_i^* w_i^*$ and $C^* = (1-\tau)Y^{H*}$,

$$\frac{\beta_i^* \alpha_i}{[1-(1+r_b)(1-\beta_i^*)]} = \gamma_i^* \tag{20}$$

for a borrower;

$$\frac{\beta_i^* \alpha_i}{[1-(1+r_s)(1-\beta_i^*)]} = \gamma_i^* \tag{21}$$

for a saver.

Finally, we can write agents' marginal propensity to consume in steady state for borrowers and savers respectively as

$$\beta_i^* = \frac{\gamma_i^* r^b}{[\gamma_i^* r^b + (\gamma_i^* - \alpha_i)]} \tag{22}$$

$$\beta_i^* = \frac{\gamma_i^* r^s}{[\gamma_i^* r^s + (\gamma_i^* - \alpha_i)]} \tag{23}$$

For a given distribution of income shares, consumption weights are randomly assigned to households and values of β_i^* are computed, so that the fraction of borrowers in the population is $0 < \eta^* < 1$.

5.2 Model modifications

In this version of the model the income shares at $t = 1$ are randomly drawn from a uniform distribution, with the conditions of being between 0 and 0.01 for each agent and their sum being equal to 1. This generates an initial distribution of income shares which is quite egalitarian. Starting from these conditions in steady state, a shock to the initial income shares distribution is introduced at time $t = 3$. In particular, the shock requires that the distribution is now much more skewed, as the shares, again drawn from a uniform distribution, must be between 0 and 0.01 and sum up to 0.6. The remaining 40% of total income

is then equally assigned to 2 agents at the top of the income distribution. This inequality shock, which is denoted as medium inequality shock, generates a higher level of inequality than the one in steady state and the resulting performance of the economy can be analyzed in detail.

Moreover, simulations are performed introducing also a low inequality shock, which generates a distribution such that 98% of the population get 80% of total income and a high inequality shock, in which the bottom 97% of the population get 40% of total income. These two, together with the medium inequality shock scenario, are compared.

These three different income distributions are intended to be a representation of three different degrees of inequality in a society, in the spirit of Piketty's (2014) analysis. In particular, these distributions vary significantly in the fraction of income earned by the lower and middle classes.

Furthermore, different fiscal policy scenarios are considered. In addition to direct government consumption analyzed also in the original model, in this version there is also the possibility to introduce a subsidy. In this case, the subsidy is introduced after the shock. The resources that are distributed as subsidies are taken from the total sum of taxes collected by the government in the same period. These taxes are divided and distributed to the part of the population which is poorest after this inequality shock, i.e. in the medium inequality shock case the lowest 98% of the income distribution.

$$y_{it}^{D} = y_{it}^{D} + s_i \tag{24}$$

where

$$s_i = \frac{\tau Y_t^H}{n-2} \tag{25}$$

for $i = 1, ..., n-2$.

When the subsidy flag is activated in the code, government expenditures enter no more in a direct way in aggregate income, but indirectly through increased consumption by households.

$$Y_t^s = AD_t^s = C_t + \pi_t^B \tag{26}$$

5.3 Simulation results

In this analysis, each experiment includes 50 independent Monte-Carlo simulations [12]. In each Monte-Carlo repetition, simulations for a series of 6 fiscal intensity parameters, which define government expenditures as percentages of steady state income, are run. As previously explained, at time $t = 3$ the economy is shocked such that the distribution of income shares becomes considerably more unequal. Tracking the evolution of aggregate income with respect to steady state income, allows for an analysis of the dynamics and the properties that can emerge in presence of an inegalitarian income distribution. The analysis starts with the medium inequality shock. Moreover, a comparison is made between two scenarios for what concerns public expenditures, one in which government consumption directly enters in aggregate income, and another one in which a subsidy is introduced after the shock, such that government consumption is targeted towards low-income households.

In this model, the algorithm that determines consumption shares takes as input income shares. Starting from a quite egalitarian income distribution, this implies that also initial consumption shares are quite equal. In turn, desired consumption is set to be equal to households initial consumption, such that also this variable takes similar values for all households. The introduction of an inequality shock, leads to a situation in which many households find themselves with a lower income share than in steady state, such that their desired level of consumption, which is assumed to be constant over time, can now be higher than the resources at their disposal. In other words, households' realized marginal propensities to consume become very high for agents who cannot satisfy their consumption plans, generally those belonging to the poorest part of the population, which, after the inequality shock, get a lower income share than before. These mechanisms are in line with empirical evidence, as previously mentioned [13]. This implies that a great number of households has to take up debt in order to sustain the same

[12] As pointed out by Fagiolo and Roventini (2016), this method permits to have a distribution of a given statistics computed on simulated variables. In fact, given the stochastic nature of the process, each Monte-Carlo run will give a different value of such statistics. By analyzing how this statistics depends on some initial parameters, one can get descriptive knowledge of the dynamics in the system.

[13] This is also in line with the work of Caiani, Russo and Gallegati (2016).

level of consumption. The pool of borrowers has, thus, now widened. Therefore, the credit supply may not be sufficient to cover all credit demand, leading to the exclusion of some potential borrowers from the credit market and to credit rationing (Jaffee and Stiglitz, 1990).

For now, let us consider the case in which a medium inequality shock is introduced and government consumption is direct, in the sense that it enters directly in aggregate income. Performing fifty Monte-Carlo simulations, the model generates data such that aggregate income as a fraction of steady-state income falls considerably after the inequality shock, as depicted in Figure 7. When the distribution becomes more unequal, many households lack the internal resources to finance desired consumption and there is a decline of aggregate demand that spurs a trend of plunging aggregate income, with the economy entering a recession, in line with Dosi et al (2016), Dosi et al. (2013) and Cardaci (2014). The figure also reports the evolution of aggregate income over time, for different fiscal intensity parameters, which define government expenditure as a fraction of steady state income. The smaller this parameter is, the deeper is the downturn, suggesting that a more active government dampens the negative effects given by the presence of a highly skewed distribution.

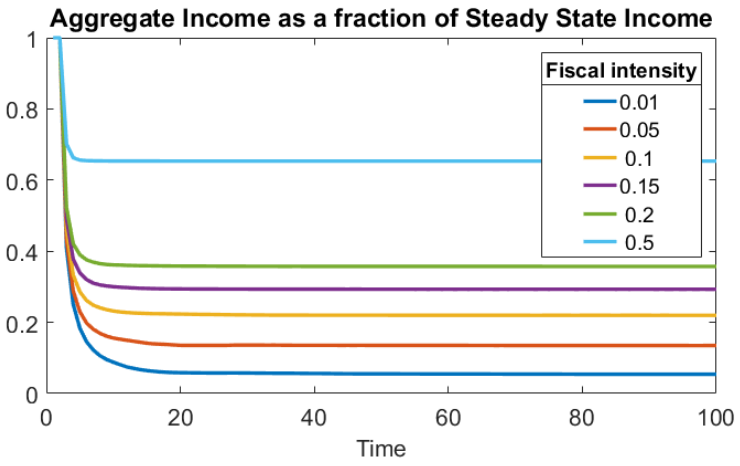

Figure 7: Evolution of aggregate income as a fraction of steady state income. Each point on the graph is an average of 50 independent Monte-Carlo simulations.

In fact, in case of an unequal distribution of income, higher levels of public expenditures reduce the differences in aggregate output between the inegalitarian case and the more egalitarian steady state case. Figure 7 also shows how the shock leads the economy to a lower steady-state level. This is true for every

fiscal intensity parameter considered. For example, for 15% fiscal intensity, the maximum fall of aggregate income leads to a level of 29% of steady-state income, as reported in Table 4 and it is visible from the graph that, throughout the whole period, aggregate income is quite constant after the inequality shock, suggesting that in unequal economies aggregate output stays persistently at lower levels, compared to the case with a more equal distribution.

Let us now analyze the behavior of fiscal multipliers in this model. They are calculated as a fraction between the variation in aggregate output between two scenarios with different fiscal intensities and the variation of government consumption in these two different cases. The baseline level of fiscal intensity z is the one in which government consumption corresponds to 1% of steady state income.

$$m_h^{fr}(t) = \frac{Y_h^{fr}(t) - Y_z^{fr}(t)}{G_h^{fr}(t) - G_z^{fr}(t)} \quad \text{with } h \neq z \tag{27}$$

This analysis, summarized in Figure 8, shows how fiscal multipliers are state-dependent and time-varying and are higher for lower levels of aggregate income, for a given income distribution shock. In fact, when aggregate income reaches extremely low levels after the inequality shock, active government expenditures can provide a stimulus to the economy and may, thus, have a stronger impact on the evolution of aggregate income. In other words, there is a bigger "fiscal space" in this case, when the crisis is more evident.

All peak fiscal multipliers found in this analysis are, in fact, significantly higher than one, in line with Auerbach and Gorodnichenko's (2012) empirical findings about the high levels of multipliers during recessions. Moreover, it is visible from Figure 8 how fiscal multipliers constantly stays at levels which are higher than one, for every fiscal intensity parameter. This is in line with empirical research showing that multipliers are higher under tight credit market conditions (Ferraresi et al., 2014). In fact, the degree of credit rationing in the economy, can help explaining the evolution of fiscal multipliers [14].

[14]Standard models have not taken the role of fiscal multipliers in macroeconomic dynamics seriously, since they have underestimated their magnitude (Blanchard and Leigh, 2013). This has led to a poor understanding in the economic discipline of the potential positive effects fiscal policies could have on the economy. As the other side of the coin, economists and policy-makers have overseen the destructive consequences fiscal consolidation policies can imply. Dosi et al.

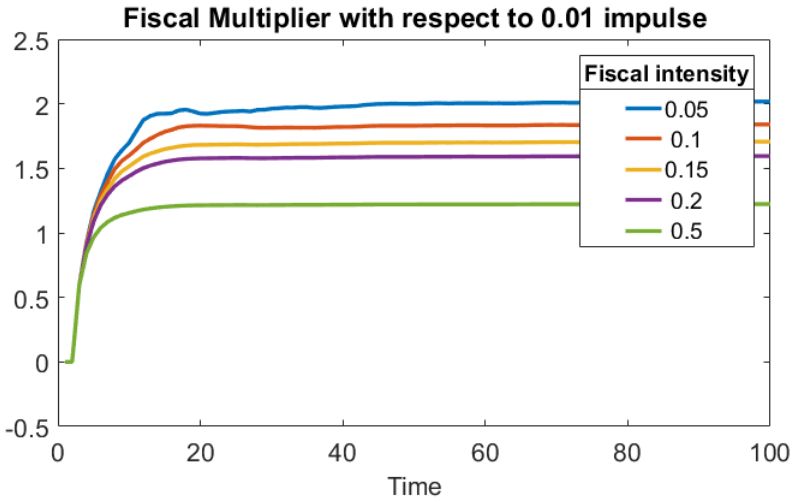

Figure 8: Evolution of fiscal multipliers with respect to 0.01 fiscal impulse. Each point on the graph is an average of 50 independent Monte-Carlo simulations.

For this reason, let us analyze the evolution of the fraction of constrained borrowers after the shock. This large increase in the number of constrained households, visible in Figure 9, results from the dynamics previously explained, for which higher inequality widens the pool of potential borrowers, who are unable to satisfy their consumption plans relying on their wealth only. Therefore, credit supply is not sufficient to satisfy credit demand and a higher portion of borrowers becomes credit constrained. Households which are denied access to credit consume less than their desired level and, hence, aggregate consumption falls, implying a fall in aggregate income. These findings are in line with Cardaci and Saraceno (2015), in which credit constraints together with wider inequalities generate a fall in aggregate demand and output. Again, government consumption can dampen these negative effects, and this is why a lower fraction of constrained borrowers corresponds to a higher fiscal intensity parameter. Moreover, in an economy with a higher fraction of constrained borrowers, fiscal multipliers are higher, as an increase in public expenditure increases aggregate output relatively more, since aggregate consumption is relatively lower.

Some households can also default. In fact, at the end of each period, households have to pay back their debt with interests. When this amount that has to be paid back is greater than the resources households have at their disposal,

(2015), with the help of an agent based model, find that austerity policies considerably harm the economy.

they go bankrupt. In this case, the bank gets a loss and this decreases the credit supply in the subsequent period, increasing the degree of credit rationing in the system. Moreover, bankrupted households' wealth is set equal to zero, as well as their consumption, and they are denied access to credit for a given amount of periods. For this default number of periods households are obliged to consume less than their desired levels. Hence, this mechanism further depresses aggregate demand and income. In this analysis the number of households that default is limited. For example in this case with a medium inequality shock and direct government consumption, the maximum number of bankruptcies is of 8 out of 1000 households in one period, for the lowest fiscal intensity parameter. However, as stressed in Napoletano, Roventini and Gaffard (2015), even a small fraction of bankrupted households can generate a negative spiral of declining consumption and output. Therefore, this mechanism which emerges as a consequence of the inequality shock should be taken into account as a possible additional destabilizing effect.

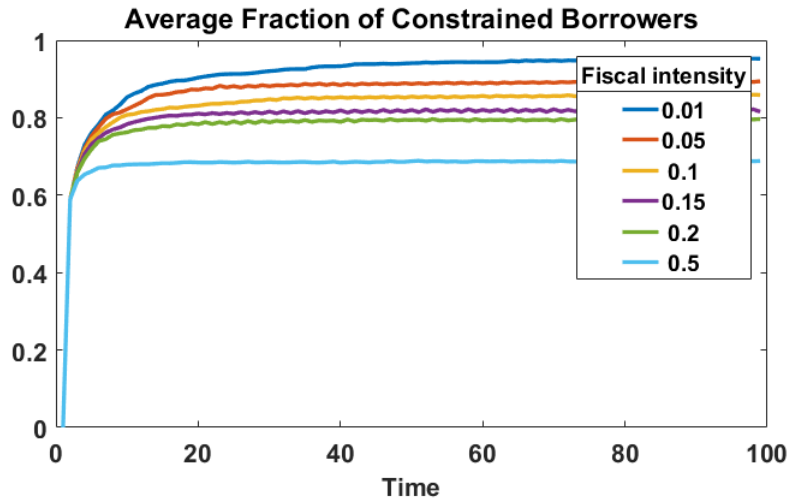

Figure 9: Evolution of the average fraction of constrained borrowers. Each point on the graph is an average of 50 independent Monte-Carlo simulations.

Trying to connect all the links, a summary of the dynamics in the model explaining this extreme increase in the average fraction of constrained borrowers and, with it, a downturn in aggregate income is presented. The inequality shock is introduced as a tool in the model in order to get a skewed distribution, together with an effective marginal propensity to consume, which is high for households negatively affected by the shock and low for households which find themselves

with an income share which is higher than before.

As the model is constructed such that the desired level of consumption depends on initial income, the steady state situation of the more egalitarian income distribution generates an egalitarian consumption share. Oonce the shock is introduced, many households find themselves with a considerably lower income share with respect to what they received in steady state.

For a large number of households, this income (and wealth) is not sufficient in order to attain their desired level of consumption, which is constant over time. For this reason, households have to ask for credit. As credit is allocated following a pecking order (Dosi et al. 2013, 2015), that depends on the ratio between a household's wealth and his credit demand, the total amount of credit supply may not be sufficient. Households are, thus, credit-rationed and are forced to consume less than what they would like to.

Therefore, a negative spiral of reduced disposable income which generates lower consumption, lower aggregate income and, again, lower households disposable income takes place. Indeed, households disposable income falls because of lower consumption due to an excess of credit demand with respect to the available credit supply. As a result, in the next periods, even more households could be forced to borrow in order to maintain their consumption behavior. Moreover, indebted agents are obliged to pay back their debt, both principal and interests, at the end of each period. Hence, even if they get credit in order to finance consumption, their wealth diminishes and could be eaten up by debt, in line with Koo (2011).

In the case in which a household is not able to repay its debt at the end of the period, this agent defaults, generating a loss for the bank, which, in turn, decreases its credit supply. This mechanism increases the degree of credit rationing in the economy even more. Moreover, the bankrupted agent is denied the access to the credit market for a given amount of periods, and its consumption is set equal to zero when he defaults. For the subsequent periods in which he does not have access to credit, the bankrupted household is obliged to consume less than its desired level. This implies a lower aggregate consumption, which depresses aggregate output further. The government can ensure that the private sector has

the income to repair its balance sheets, by keeping the GDP from shrinking.

5.4 Simulations with different inequality shocks

This section investigates how different degrees of inequality in households' income distribution may affect the resilience of the system to an inequality shock. Three different inequality shocks have been introduced: a "low inequality shock", in which 98% of the population get 80% of total income, a "medium inequality shock", which is the one analyzed in detail in the section above, in which the bottom 98% of the population get 60% of total income, and a "high inequality shock", in which the bottom 97% of the population get 40% of total income.

The first variable that can be analyzed is the maximum fall in aggregate income, or minimum aggregate income as a fraction of steady state income, which is generated by different inequality shocks. As visible from Table 4, when inequality increases less, as in the "low" scenario, with respect to the two other cases, the fall in aggregate income is less severe. In fact, for a given fiscal intensity parameter, the minimum level of income reached as a consequence of the inequality shock is higher, the higher is the degree of concentration in the income distribution.

As in the medium inequality case, analyzed in detail in the previous section, for each inequality scenario, the higher is the fiscal intensity, the higher is the minimum level of aggregate income reached. For this reason, one can conclude that government spending acts as a parachute against the fall in incomes for whatever shape of the distribution of income shares.

Table 4: Minimum aggregate income as a fraction of SS income for low, medium and high inequality

Fiscal intensity	Low inequality	Medium inequality	High inequality
5%	20%	13%	11%
10%	29%	22%	18%
15%	36%	29%	25%
50%	69%	65%	61%

These dynamics can be explained by looking at the average fraction of constrained borrowers in the different cases. Let's compare, for example, the low inequality shock scenario with the high inequality shock case, since these are

the two in which biggest differences in the dynamics of aggregate income are observed. Figure 10 clearly shows how the average fraction of constrained borrowers is higher in the case in which the level of inequality is higher. In fact, in the case of a highly skewed distribution, the share of income earned by the bottom 97% of households is of 40%. This means that a large fraction of households has not enough internal resources at their disposal in order to finance consumption, such that they have to ask for credit. As credit is allocated using a pecking order rule, a large fraction of borrowers is credit constrained and, thus, obliged to consume less than desired.

Moreover, the generated data show that the maximum number of bankrupted households in one time step for the lowest fiscal intensity is of 7 in case of low inequality, while it is of 13 in case of high inequality. This implies that the negative effects generated by bankruptcies for which credit supply diminishes, as well as aggregate consumption and income, and for which credit rationing increases further, is more present in the high inequality scenario.

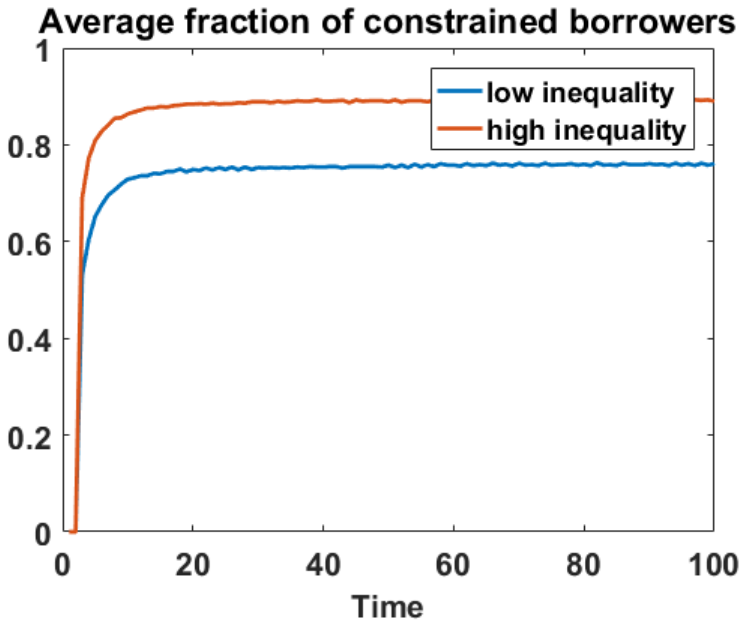

Figure 10: Average fraction of constrained households for 15% fiscal intensity parameter, low inequality vs. high inequality

Comparing the evolution of multipliers for different inequality scenarios, what emerges from Table 5 is that a less skewed distribution of income is associated with higher multipliers. This may look counter-intuitive because higher inequality is associated with higher aggregate income falls, and thus one would expect a larger

fiscal space as well. However, for high levels of inequality, the structure of the distribution of income and the presence of a high fraction of credit constrained borrowers imply that many agents are not able to repair their balance sheets and, thus, increase consumption, compared with a low inequality scenario. In fact, as public expenditure increases aggregate income, most families receive an income which is not high enough to increase consumption. A high fraction of income is indeed earned by few rich households, who save their income almost entirely. This can explain the lower effectiveness of fiscal policies in an environment of high inequality.

It can be interesting to point out that, as showed in Table 5, when government expenditure becomes very high (50% of steady state income), fiscal multipliers are very similar in the three inequality scenarios. In fact, in this case, a very active government counterbalances the difficulties in repairing households' balance sheets and in increasing consumption which are experienced in a highly unequal economy, such that fiscal policies are more effective.

Moreover, for a given inequality shock, multipliers are higher for lower fiscal intensity parameters, suggesting again the presence of a wider fiscal space. This suggests that, in any case, fiscal policy may have effect in increasing aggregate income for all three cases, as higher fiscal intensity parameters are associated with a dampened fall in aggregate income in all inequality scenarios, as visible from Figures 7 and 11 and Table 4.

Table 5: Peak multipliers with respect to 1% fiscal intensity.

Fiscal intensity	Low inequality	Medium inequality	High inequality
5%	2.47	1.93	1.50
10%	2.10	1.76	1.44
15%	1.88	1.63	1.39
50%	1.21	1.21	1.14

5.5 Simulations with redistributive policy

It can also be interesting to analyze how redistributive policies affect the performance of the economy. In this model, a subsidy given to the poorest part of the population is introduced. In particular, taxes collected are divided by households

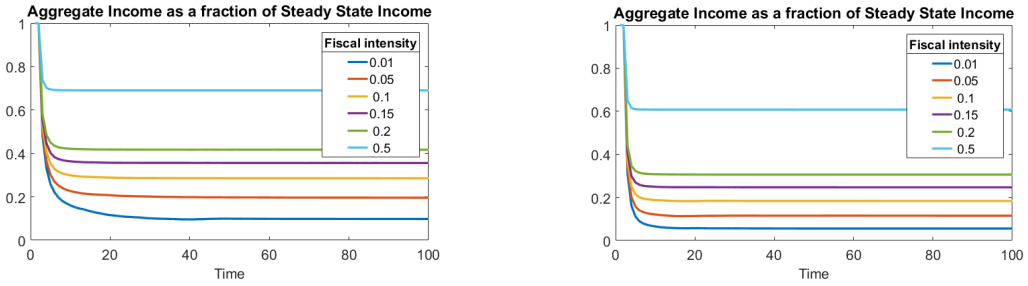

Figure 11: Evolution of aggregate income as a fraction of steady state income for scenarios with respectively low and high inequality shocks.

belonging to this group. For now let us consider the scenario with a medium inequality shock. In the next section a comparison between different inequality regimes will be made.

As a result of the introduction of the subsidy, the economy seems to face a less severe downturn, confirming empirical findings about positive effects of redistribution on the evolution of output (Ostry et al., 2014) and theoretical findings that posit that the introduction of subsidies stabilize macroeconomic dynamics (Aghion, Banerjee and Piketty, 1999; McKay and Reis, 2016)[15]. Taking as an example the case in which the fiscal intensity parameter is equal to 15%, what emerges from Table 6 is that the minimum aggregate income, measured as a fraction of steady state income, is of 36%, compared to a minimum income of 29% in the corresponding scenario without subsidy. In fact, when a subsidy is introduced after the inequality shock, credit constrained households are able to increase their consumption and to repair relatively faster their balance sheet, paying back on their debts.

Moreover, the presence of a subsidy also prevents, to some extent, the fall in households disposable income and grants a greater resilience to the economy.

The effects of the introduction of a subsidy widely differ depending on the fiscal intensity parameter. In fact, as emerges from Figure 12, for the highest value of the parameter, the fall in aggregate income is quite limited and, after

[15]Similarly, in Dosi et al. (2013) unemployment benefits have a positive effect on dampening economic fluctuations. Caiani, Russo and Gallegati (2016) find that minimum wages foster economic development.

some periods, the subsidy allows the economy to attain a level of aggregate income which is close to the initial one, given by the more egalitarian distribution of income. This is because the government has a higher amount of resources at its disposal to be used for redistributive purposes. Therefore, in this scenario with 50% fiscal intensity, a high government expenditure in the first periods reduces the fall in aggregate output, and, combined with the introduction of the subsidy after the inequality shock, it allows the economy to quickly recover from the crisis, almost fully.

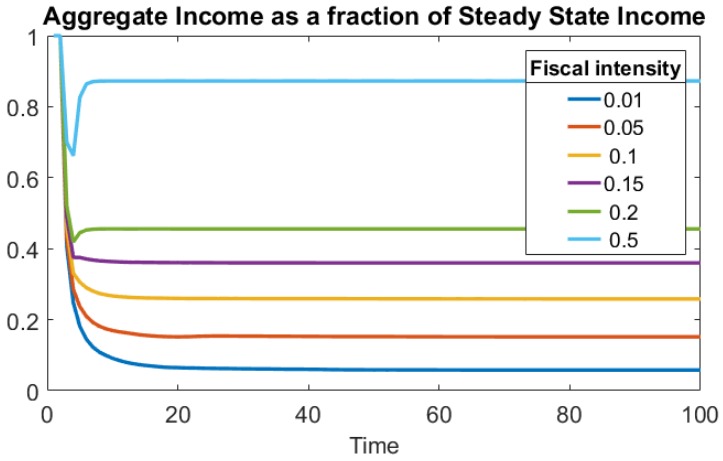

Figure 12: Evolution of aggregate income in the scenario with a subsidy and medium inequality shock. Each point on the graph is an average of 50 independent Monte-Carlo simulations.

Table 6: Minimum aggregate income as a fraction of SS income, medium inequality shock. Direct government expenditure vs. subsidy.

Fiscal intensity	Direct government expenditure	With subsidy
5%	13%	15%
10%	22%	26%
15%	29%	36%

Table 7: Maximum multiplier with respect to 0.01 fiscal impulse. Medium inequality. Direct government expenditure vs. subsidy.

Fiscal intensity	Direct government expenditure	With subsidy
5%	1.93	2.24
10%	1.76	2.20
15%	1.63	2.12

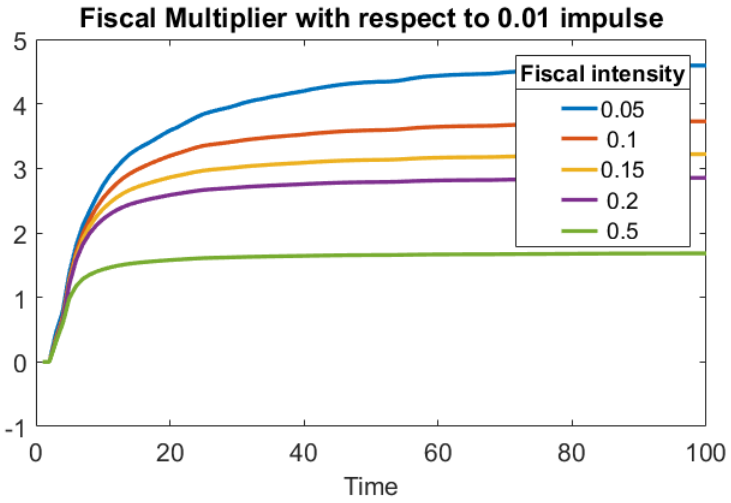

Figure 13: Evolution of fiscal multipliers with respect to 0.01 fiscal impulse in the subsidy scenario, medium inequality shock. Each point on the graph is an average of 50 independent Monte-Carlo simulations.

Comparing multipliers for the cases with subsidy and with direct public expenditure, it turns out that the multiplier is higher in the first case. Taking again as example the case with a fiscal intensity of 15 percent, Table 7 shows that the value of the multiplier is equal to 2.12 with subsidy, while it is equal to 1.63 in the scenario without this redistributive policy. In other words, the subsidy has a bigger effect on aggregate income than direct public expenditure. This mirrors the phenomenon for which increasing poor households' disposable income makes a higher number of agents able to attain their desired level of consumption, increasing aggregate consumption and, thus, aggregate income relatively more than if these resources were directly summed up to aggregate income. This higher multiplier effect results in a higher aggregate income, relatively to the scenario without subsidy, which can be distributed to the population and help the economy recovering, at least partially, from the recession.

To sum up, the introduction of a redistributive policy, such as a subsidy, not only attenuates the fall in aggregate income due to an inequality shock, functioning as an automatic stabilizer, but it is also more effective than government consumption.

Figure 14 helps explaining the wide disparities in the evolution of aggregate income coming along with the introduction of the subsidy. For instance, the subsidy, together with a high fiscal impulse, allows households belonging to the

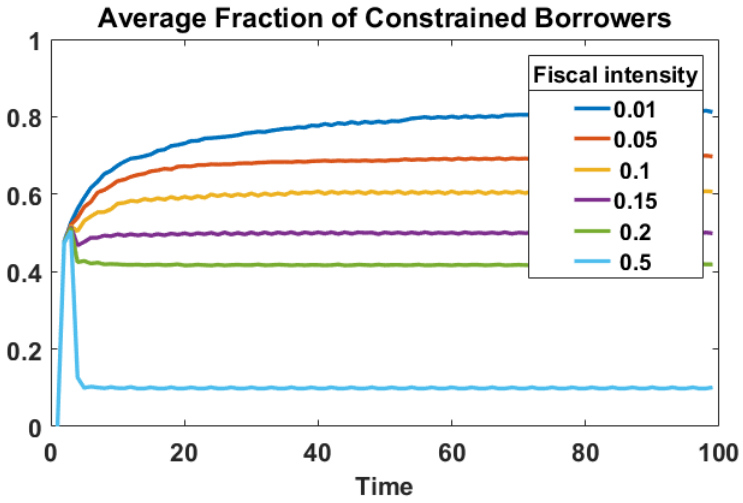

Figure 14: Evolution of the average fraction of constrained borrowers, scenario with subsidy. Medium inequality shock. Each point on the graph is an average of 50 independent Monte-Carlo simulations.

lowest deciles of the income distribution to have sufficient resources in order to satisfy their consumption needs. For this reason, the fraction of the population who needs credit in order to satisfy their consumption plans is now lower and, in turn, the fraction of constrained households decreases.

A high fiscal intensity, particularly the highest one of 50%, helps most households in satisfying their consumption plans, through higher subsidies, and sustains aggregate consumption. This increases significantly aggregate income. On the opposite, for what concerns the lowest fiscal intensity of 1%, the available amount of resources which can be distributed as subsidies is not enough in order to change poor households' financial situation. A large fraction of households would like to consume more than what they are able to with their wealth and, as the bank supplies a limited amount of credit, the fraction of constrained borrowers is extremely high. The subsidy in this case is not enough in order to repair their balance sheet and increase considerably their consumption. In fact, as visible from Table 6, the increase in aggregate income as a consequence of the introduction of a subsidy, is higher, the higher the fiscal intensity parameter.

5.6 Simulations with redistribution for different inequality shocks

Performing simulations in which a subsidy is given to the part of the population which gets a low income share for different inequality scenarios, what emerges is that the subsidy limits the fall in aggregate income for each of the three cases and for each fiscal intensity parameter. Table 8 takes as an example the case in which the government spends an amount equal to 15% of steady state income. Comparing for each inequality shock the baseline case of public spending without subsidy with the case in which a subsidy is introduced, the minimum income reached after the inequality shock is higher with the subsidy in all three cases.

Moreover, even after the introduction of the subsidy, the minimum aggregate income is reached in the high inequality case, such that a lower inequality combined with the subsidy is the scenario which limits the fall in aggregate income the most.

Table 8: Minimum aggregate income as a fraction of SS income for low, medium and high inequality. Direct government expenditure vs. subsidy. 15% fiscal intensity.

Inequality shock	Direct government expenditure	With subsidy
Low	36%	43%
Medium	29%	36%
High	25%	30%

Again, the subsidy allows indebted households to repair their balance sheets. The result is an increase in aggregate consumption which attenuates the fall in aggregate income. Figure 15 shows how also for the cases relative to a low inequality shock and a high inequality shock, the highest fiscal intensity parameter allows to quickly get to a new steady state which is much higher with respect to the ones related to the other fiscal intensity parameters.

Moreover, Figure 16 shows how the introduction of a subsidy can drastically change the evolution of aggregate income, when the fiscal intensity parameter is high. In particular, it compares the evolution of aggregate income in the two different government expenditure regimes for the high inequality scenario with 50% fiscal intensity. The subsidy allows the economy to partially recover from

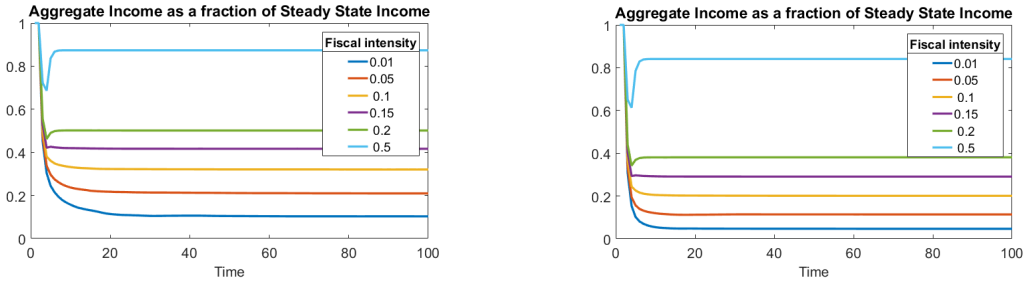

Figure 15: Evolution of aggregate income as a fraction of steady state income for scenarios with respectively low and high inequality shocks and with subsidy.

the downturn, and this is due to a fall in the average fraction of constrained households.

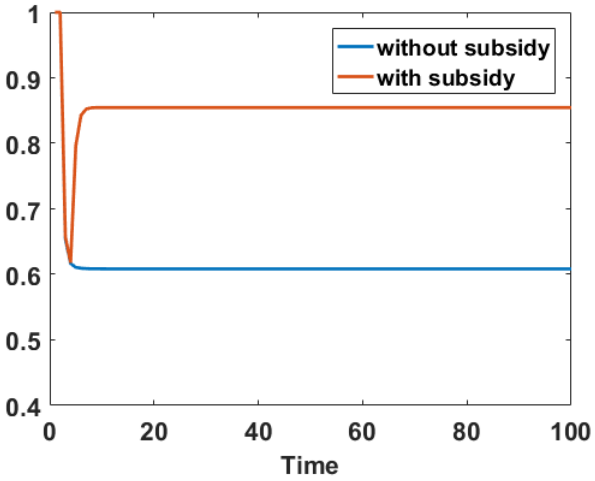

Figure 16: Evolution of aggregate income as a fraction of steady state income in the high inequality scenario with 50 percent fiscal intensity

Figure 17 tracks the evolution of fiscal multipliers for the scenario with the inclusion of a subsidy, respectively for low and high inequality shocks. What emerges from a comparison is that fiscal multipliers are higher when inequality is lower. This is again connected to the dynamics in the model for which, in presence of low inequality, more households can gauge from an increase of aggregate income, such that they can increase consumption.

For what concerns the evolution of the average fraction of credit constrained households, this is lower for a less skewed distribution of income than fore a more concentrated one at every time step, as visible from Figure 18. This explains the fact that a lower level of inequality, together with the introduction of a subsidy, is

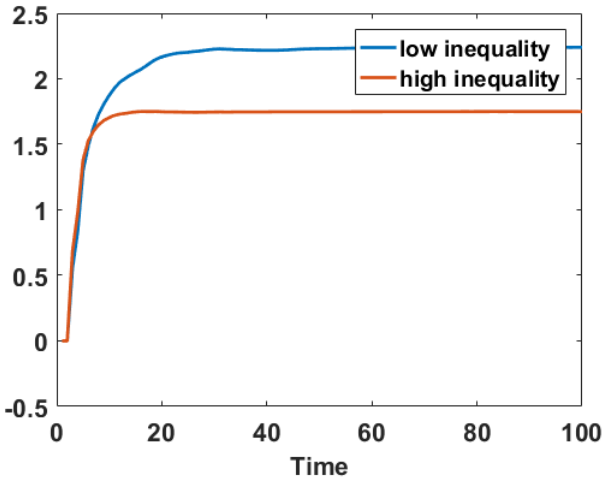

Figure 17: Evolution of fiscal multipliers for 0.15 fiscal intensity with respect to 0.01 fiscal impulse in the scenario with subsidy, low and high inequality shock. Each point on the graph is an average of 50 independent Monte-Carlo simulations.

associated with a less severe fall in aggregate income, with respect to the scenario with a high inequality shock, as less households lack the internal resources to satisfy their consumption plans.

Furthermore, this could help explaining why fiscal multipliers are lower in the high inequality scenario. In fact, the consumption of credit constrained consumers is bound by their wealth, which is very low in a system characterized by a highly skewed distribution. By increasing income levels, fiscal expenditure allows constrained borrowers to repair their balance sheets and to increase their consumption levels, but relatively less than in the framework with low inequality.

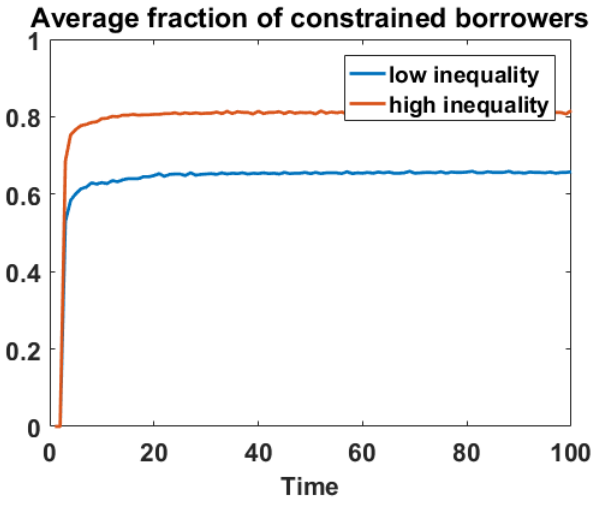

Figure 18: Evolution of average fraction of constrained borrowers in the scenario with subsidy, low and high inequality shock.

Interestingly, it can be noticed that, for every inequality scenario, the subsidy allows a higher fiscal multiplier effect for every given parameter of government expenditure. This is confirmed in Table 9, in which, as an example, peak multipliers for 15% fiscal intensity with respect to 1% fiscal intensity are reported. Comparing the direct government expenditure scenario with the one with the subsidy, for each inequality shock, the value for the peak multiplier is higher in the case with the subsidy.

Table 9: Maximum multiplier for 0.15 fiscal intensity parameter with respect to 0.01 fiscal impulse. Direct government expenditure vs. subsidy.

Inequality shock	Direct government expenditure	With subsidy
Low inequality	1.88	2.24
Medium inequality	1.63	2.12
High inequality	1.39	1.74

6 Conclusions

In this work, an extension of the analysis carried out by Napoletano, Roventini and Gaffard (2015) with an agent-based model has been presented. In this version of the model, the system is characterised by heterogeneous agents in terms of wealth, income and marginal propensities to consume and by constraints in the availability of credit. The analysis starts with a situation of very low inequality. Then, an inequality shock is introduced and the evolution of aggregate income, fiscal multipliers and average fraction of constrained borrowers is tracked. This inequality shock has been indicated as a medium inequality shock. The analysis has been carried out also for two other inequality shocks, respectively indicated as low and high. Moreover, a subsidy is introduced in the aftermath of the shock, in order to grasp the effect of a redistributive policy.

The main conclusions are that the inequality shock persistently worsens the performance of the economy in terms of aggregate income. This is due to reduced aggregate consumption. In fact, with higher inequality, many households find themselves with an insufficient amount of resources in order to maintain their consumption habits, such that they ask for credit. The pool of borrowers widens, and, as the credit availability is limited, the fraction of constrained borrowers increases as well. These credit constrained households are those having the highest realized marginal propensity to consume in the population, but, as a result of the increased inequality, they are obliged to consume less than their desired level of consumption.

The fall in aggregate income is dampened by a higher government spending which limits the fall in households' disposable income. In fact, the fraction of constrained borrowers is, for higher fiscal intensity parameters, relatively lower and, in turn, aggregate consumption is more sustained.

These results are analogous for the other two inequality shock scenarios as well. However, the maximum fall experienced by aggregate income is higher, the higher the level of inequality introduced in the system. This can be explained by the presence of a higher fraction of credit constrained borrowers in the high inequality scenario. In fact, households have similar consumption desires throughout the income distribution, such that in a more unequal economy, there is a

higher portion of households which has not enough internal resources in order to finance consumption. For what concerns fiscal multipliers, these are lower in the case in which the personal income share distribution is less skewed. This result may seem counter-intuitive because higher inequality is associated with higher aggregate income falls, and thus one would expect a larger fiscal space as well. However, for high levels of inequality, the structure of the distribution of income and the presence of a high fraction of credit constrained borrowers impede agents in repairing their balance sheets and, thus, in increasing consumption, compared with a low inequality scenario. However, all peak multipliers are in any case greater than one.

In the scenario in which a subsidy is introduced, the maximum fall in aggregate income is always lower than in the case without such a policy, for every fiscal intensity parameter. In fact, the subsidy sustains households' disposable income after being negatively hit by the inequality shock, such that they have to ask for less credit in order to satisfy their consumption plans. In this way, the average fraction of constrained borrowers is lower. The positive effect of the subsidy is, as one would expect, stronger the higher the fiscal intensity parameter. In fact, when the government spends fifty percent of steady-state income, the economy recovers from the downturn almost completely. Finally, the subsidy is more effective than direct government expenditure, as indicated by the higher fiscal multipliers.

For what concerns the comparison between different levels of inequality shocks, it turns out that the subsidy dampens the recession in every scenario. Moreover, for a given fiscal intensity parameter the fall is lower, the lower is the level of inequality in the economy. It also emerges that in more unequal economies, the maximum fiscal multiplier is lower than in less unequal economies. In all scenarios, the subsidy turns out to be more effective in dampening the magnitude of the shock than direct government expenditure. Hence, this policy works as an automatic stabilizer for the economy, lowering the volatility of the system. This is in line with recent findings by McKay and Reis (2016), for which higher transfers to the unemployed and poor are indeed effective at lowering the volatility of aggregate output.

As an extension of the analysis, it could be interesting to investigate what

happens when desired consumption is not constant over time. In particular, a possibility could be to analyze the effects on the system of different consumption behaviors of low-income households. For example, a recent empirical study performed by Krueger, Mitman and Perri (2016) on the behavior of households in the aftermath of the recent crisis, shows evidence for a reduction of consumption by this class of households which is greater in magnitude than the fall in their income. Another interesting research path to follow could be to introduce rules for consumption behavior in line with Duesenberry (1949), as based on habits and on social interdependencies.

It could also be interesting to include different forms of fiscal policy, as a progressive tax on income and wealth. Another possible extension could be to analyze what happens in the three different inequality scenarios when the credit supply increases and to see if the increased indebtedness may amplify the risk for crisis, even if it initially allows for higher consumption, as for example found by Cardaci and Saraceno (2015). Otherwise, one could introduce some prudential policy for which the bank builds a counter-cyclical capital buffer, in line with Basel III guidelines (BCBS, 2011). Moreover, different consumption goods could be introduced.

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